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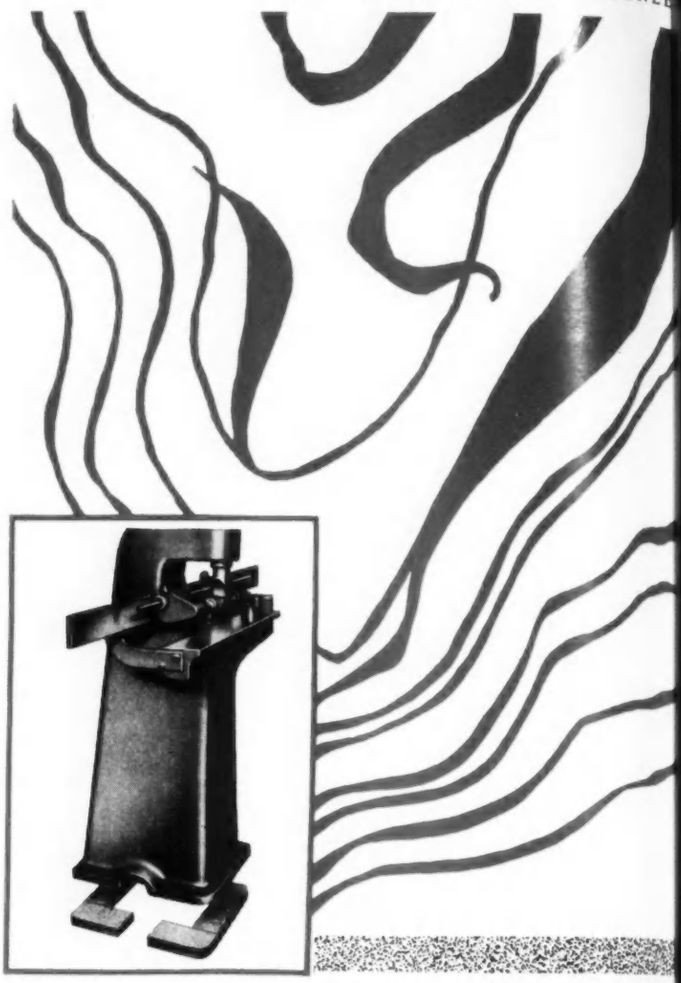

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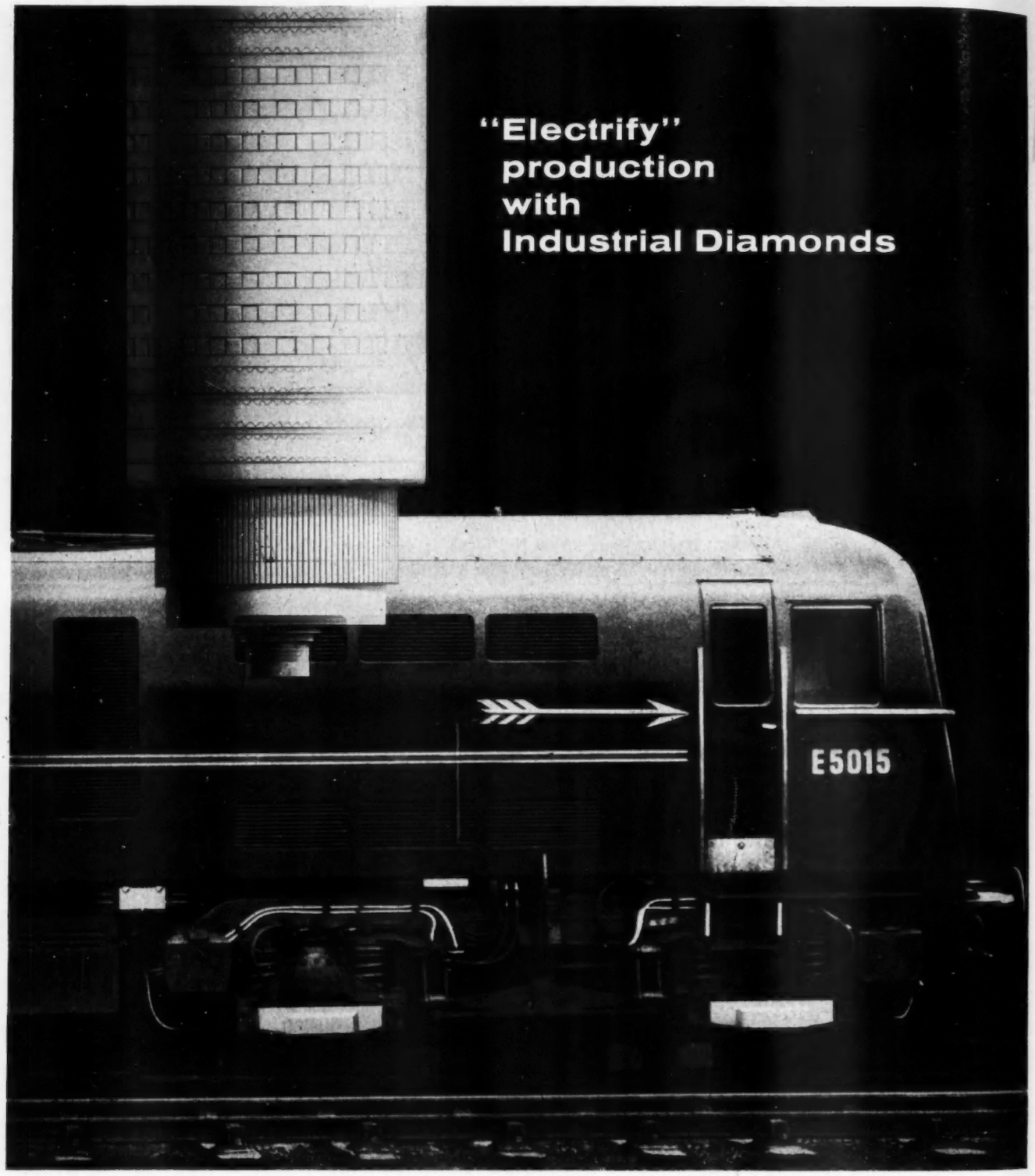

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THE ENGINEER

No. 5525 DECEMBER 15, 1961 Vol. 212

ATLANTIC CROSSING BY RADIO

Tuesday of this week was the sixtieth anniversary of the first wireless message being transmitted across the Atlantic. An article on another page recalls this achievement of Guglielmo Marconi and its consequences, for the whole structure of world-wide radio communication is founded on the impetus given to experiment and investigation by the knowledge that the scratchy note of a spark transmitter at Poldhu in Cornwall had been heard in Newfoundland. Visitors to a special exhibition opened on Wednesday at the Science Museum, South Kensington, can see examples and replicas of the apparatus of the time, but the actual equipment used on that historic December 12, 1901, seems for the most part to have been dispersed in a manner all too familiar. The Hornsby-Ackroyd oil engine which drove the generator for the Poldhu transmitter on that occasion still works in a Cornish laundry and may escape oblivion. Other parts of the installation must have been scrapped or rebuilt when they had served their purpose. The makers of history were pressing forward too fast to be concerned with preserving relics. It is not hard to understand how the urge to improvement would cause circuits to be re-wired and components to be modified until originals melted away. Even the diary in which Marconi recorded hearing the signals from Poldhu was used later as a rough notebook, and pencilled jottings almost obscure the significant entries. In the absence of wavemeters, the very wavelengths of the experiments were unrecorded and can only be placed by conjecture as between 1000 and 2000 metres. It is well known, however, that for some two decades afterwards the idea persisted that long waves were best for long distance, although the advantages of long-distance transmission at night were established during further experiments in 1902. Later knowledge shows Marconi's achivement as all the more remarkable. Working on the "wrong" wavelengths at the "wrong" time, he showed the world that a new medium of international communication was at hand. But how wrong was he? A return swing to low frequencies has already begun for certain services.

DEBATE ON SPACE RESEARCH

The Lords are notably good at debating scientific and research subjects. They debate them with decorum and they can disagree without heat. Last week they debated space research. Lord Halsbury on the whole seemed to be against spending much money on it. Though he supported the ideas behind the European Space Research Organisation and the European Launcher Development Organisation—as did almost everyone else in the debate—he seemed not at all keen about the development of space rocketry in this country. His was, indeed, the scientists' view that, if possible (for example by renting space in American or Russian rockets) Britain should concentrate expenditure "on the important part, which is the instrumentation." He was also the scientist in stressing that there were other scientific fields in which advances could be made more cheaply and with greater advantage to the human race. In effect he was repeating what scientists are so fond of saying, that mankind does not make full use of the scientific knowledge it already possesses. But when such arguments are carried so far as to suggest that Britain should leave the Americans and the Russians to develop space rocketry—Lord Halsbury seemed almost to go so far—engineers must rebel. For if this country is to flourish in the future —the point has been reiterated *ad nauseam* without affecting its truth — it must retain a place amongst the more advanced of technological nations. It must learn the techniques of space rocketry because in a number of respects they are in advance of existing engineering techniques. Lord Halsbury rather cried down what he called the "fringe benefits" of rocketry and space research, but in reality their value is quite incalculable. One must judge by analogy. On any economic assessment this country's expenditure between the wars upon the building of the airships "R100" and "R101" resulted in a dead loss of many millions of pounds. But such people as Professor Pippard, Sir Arthur Pugsley and Sir Harold Roxbee Cox, whose names happen to come to mind amongst many more and all of whom had the experience of working upon the varied problems set by the design, construction and operation of those airships, might well argue that in relation to the technological advances made the price of the effort was quite low. How much engineering in general will eventually benefit from the development of rocketry and space research it is not possible to tell. But apart from the foreseeable benefits to world communications one other thing can be discerned already. When a space rocket is fired the failure of any one of its components leads to the failure of its mission and the loss of all the money invested in it and its payload. In no other engineering device, not even in aircraft, is the same thing wholly true. The failure of certain components may, indeed, prove disastrous; but not the

failure of any. Thus in designing and making components for rockets engineers are having to face requirement for a standard of reliability hitherto almost unknown. Moreover that very high degree of reliability has to be attained in highly stressed devices. All engineering products are likely eventually to benefit from the knowledge gained. How can one assess such an advance in terms of money?

TACTICAL NUCLEAR WEAPONS

After a year of threats, the Berlin trouble has now become more of a problem than a crisis. Once President Kennedy, supported by his allies, had intimated that access to the city and the freedom of the West Berliners was a vital interest, it ensured that Mr. Khruschev would negotiate. Indeed it says much for the wisdom of the deterrent policy, since Berlin is the only area in Europe where he could with comparative ease present N.A.T.O. with a *fait accompli*. But the Berlin problem has also shown that there must be a more sensible means for the N.A.T.O. powers of settling a serious dispute than to resort to the threat of a mass destruction war. Hitherto the peoples of the West have been following their lawful occasions confident in the belief that there could be only two possible causes for a war of that kind and that both should and would be avoided. The West's stipulation has always been that there must be no further Soviet occupation of the territory of any N.A.T.O. nation. Equally Russia has made it clear that she would resist with every weapon at her disposal any attempt by Germany to reunite under Western auspices and again become a great military power. Meanwhile the Western nations have looked upon the constant flow of refugees from East Berlin as evidence of a desire for freedom rather than as a likely source of future trouble. None the less the Berlin problem seems likely to result in good rather than harm in that it has brought home to N.A.T.O. the need for stronger conventional forces and in raising doubts among the N.A.T.O. planners whether nuclear weapons of any kind should be used at all, except as a last resource.

Because the Soviet Union is now in a position of equality with the West in strategic nuclear weapons and the Shield in Europe is under strength it has been the policy in recent years for Britain's conventional forces in Europe to be equipped with and use tactical nuclear weapons to make up for their deficiency in numbers. What possible logic can there be in a defence policy of this kind unless, contrary to all evidence, it is to be assumed that Russia has entirely neglected to develop tactical concurrently with her strategical nuclear weapons? What has in fact happened is that a position has been reached of nuclear stalemate with tactical as well as strategical nuclear weapons. Indeed, in respect of tactical weapons their use would give the Russian forces, in view of the much larger number of troops at their disposal, the obvious advantage of being less affected by the much greater casualty rate to be expected. The only sensible and logical defence policy for N.A.T.O. to adopt in Europe is to return to the original aim of the Shield. This was to hold a "probing" attack or minor aggression — to prevent the West being presented with a *fait accompli* — and thus to give time for the Soviet leaders to think again before the Western nations felt obliged to start a mass destruction war. Most certainly the Shield should be equipped with tactical nuclear weapons. But N.A.T.O. troops and tactical air forces should on no account use them on the battlefield unless and until the Soviet forces did so, thus making it clear their attack was not just a "try-on", but a deliberate and pre-determined aggression, started in the full realisation that the use of mass destruction missiles was likely to follow. This surely is in line with the Foreign Secretary's statement in the Lords earlier this year: "The development of nuclear weapons during the past few years" he emphasised "has been so revolutionary that it is no longer possible to put them tidily into categories marked 'strategical' or 'tactical'. A weapon is strategic or tactical according to where it is sited and the targets allocated to it." In this connection it is worth bearing in mind that the missile which devasted Hiroshima over 16 years ago is now well within the so-called tactical range. Could it be aimed at a railway centre a hundred miles behind the fighting front without destroying the villages surrounding the centre? Or is it to be claimed that it is not a strategic weapon because the yield of a one-megaton bomb is fifty times greater?

In brief, given that Communist aggression in Europe is still regarded as credible, the N.A.T.O. powers should aim to raise the threshold at which tactical nuclear weapons are used by either side and thus do everything within their power to avoid the holocaust which would inevitably follow. Happily this seems to be the policy now favoured by President Kennedy and his advisers and it is much to be hoped that Germany will not be the only European nation to supply at least the quota of conventional forces for the Shield originally planned for each country to hold a "probing" attack.

The Engineer—100 Years Ago (DECEMBER 13, 1861)

The Smithfield Show

There were occasions in the past when we did not hesitate to express our disapproval of a machine. The Smithfield Show of 1861 provided such an occasion. One " diminutive " self-propelled engine prompted the comment " The boiler had flat sides, the makers having ascertained, we suppose, that square boilers are stronger than round ones." Nor was this all. " A pinion on the engine shaft geared directly into an internal wheel—which might be ½in, and possibly ¾in wide across its face—this wheel or circular rack forming part of the propelling wheel of the engine." Then, too, the main flywheel shaft was so close to one of the road wheels that pebbles brought up by the wheel " . . . must either be crushed or the shaft must bend."

Still, not all was bad. The engines of Ruston, Proctor and Co. and some other well-known makers were praised and the city of Lincoln was marked for the " . . . galaxy of talent and enterprise in the portable engine making line " to be found there. Perhaps both the praise and the criticisms would have been more freely forthcoming had some of the exhibits been more accessible. As it was, the committee had " . . . packed upwards of a dozen of the engines so closely together that no sixteen-stone farmer, and only very thin reporters, could get among them."

Diamond Jubilee of Transatlantic Radio

Sixty years ago this week radio signals transmitted in Great Britain were heard for the first time on the other side of the Atlantic. The following article describes the achievement of Marconi and his collaborators, and its effect on the subsequent history of long-distance radio communication. Guglielmo Marconi is illustrated here with the receiving apparatus installed for his experiment in a room of the old Barracks Hospital on Signal Hill at St. John's, Newfoundland. It was here that he and his assistant, Kemp, heard and identified the Morse letter " S " transmitted from Poldhu in Cornwall.

DURING the early 1890's, many of the leading physicists were closely interested in the properties of " Hertzian waves " but none expressed a thought that these waves would be of value for communication. In 1895, however, Guglielmo Marconi, working on their possibilities in this direction at his parents' residence at Pontecchio in Italy, discovered the great increase in range which could be obtained by the use of an elevated aerial. It was this discovery which paved the way for the use of Hertzian waves in a practicable system of wireless telegraphy.

Early in the following year, 1896, Marconi arrived in England and applied for the world's first patent for wireless telegraphy. He had chosen to come to England partly because this country was then the most powerful maritime nation in the world and it seemed likely that wireless telegraphy would be of value to shipping ; and partly because of a national affinity, his mother being Irish.

Marconi spent the next four years in an almost continual round of experiment, development and demonstration, his object being continually to improve the reliability and range of his apparatus. At first only covering a mile or so on Salisbury Plain, he was soon communicating regularly from Alum Bay, near the Needles in the Isle of Wight, to Bournemouth and then to Sandbanks at the entrance to Poole Harbour, a distance of 18 miles. In March, 1899, he spanned the English Channel and early in the following year he set up reliable communication from the Isle of Wight to The Lizard in Cornwall, a distance of 186 miles.

The shipping companies had shown mild interest but very little enthusiasm to instal wireless equipment on their ships. It seemed, in fact, that far greater ranges and a chain of land stations would be required before wireless telegraphy would have a wide appeal. The scientists of the day, however, were almost united in believing that wireless waves, like light waves, would not follow the curvature of the earth. Therefore, they said, really long ranges were impossible. Marconi thought otherwise. Experiments had led him to believe that the key to longer ranges lay in the employment of larger aerials and higher transmitter powers. He therefore determined to build two super-power transmitting stations one on each side of the Atlantic, and to attempt two-way communication. Accordingly, one site was selected at Poldhu in Cornwall, and the other at Cape Cod in Massachusetts.

It is difficult to visualise the stupendous problems which confronted him. The aerial system, at both Poldhu and Cape Cod, was of a size and complexity which had never been attempted before, for it consisted of twenty 200ft masts in a circle with an inverted cone of about 400 wires leading down to the transmitter. As to the transmitter itself, it was to be a hundred times more powerful than any hitherto built, and no precedents whatever existed for the design. Marconi delegated the responsibility for this to his scientific adviser, Professor J. A. (later, Sir Ambrose) Fleming, and Fleming carried it out brilliantly.

The prime mover for the generation of power was a Hornsby-Ackroyd oil engine which drove a Mather and Platt 2kV 50 c/s alternator (Fig. 1). This was capable of delivering 25kW, although from a paper read by Fleming to the Royal Society of Arts in December, 1921, it would appear that the plant was considerably under-run at the time of the transatlantic tests. The transmitter proper, the circuit of which is shown in Fig. 2, embodied a form of the then new " syntonic " (variable inductance) tuning, adapted by Marconi for the purpose of obtaining optimum transference of power from the transmitter output to the aerial circuit. Tuning was obtained by means of tappings on inductance *L*, the adjustment being made for maximum reading on aerial ammeter *a*. Two 20kW Berry transformers (T_1, T_2) were parallel-connected to step up the input voltage to 20kV. This was fed through r.f. chokes (*t*) to a closed oscillatory circuit in which a capacitor discharged across a spark gap via the primary of a " jigger " or r.f. transformer. Coils *w* in association with the capacitor tuned this circuit to the l.f. transformer. The secondary of the r.f. transformer was connected to a second spark gap and capacitor, and to the primary of a second r.f. transformer, the secondary winding of which was in series with the aerial. Keying was effected by short-circuiting the chokes in the alternator output.

The capacitors, seen in Fig. 3, were made of twenty glass plates, each 16in square, backed on one side with 1 square foot of tinfoil. The plates were immersed in linseed oil contained in stoneware boxes ; each box had a capacity of approximately 0·05 mfd.

Both the Poldhu and Cape Cod stations were all but ready when a double catastrophe struck ; severe gales wrecked the aerial arrays and masts at both stations almost simultaneously. With £50,000 already spent on the project, Marconi elected not to wait until both stations were repaired. Instead, a new aerial system was erected at Poldhu, consisting of fifty-four copper wires arranged in a fan shape and upheld by a triatic slung between two 150ft masts. The current into the bottom of this aerial is stated by Fleming to have been 17A and the radiated frequency is thought to have been between 100–150 kc/s. No one knows for certain, however, as no

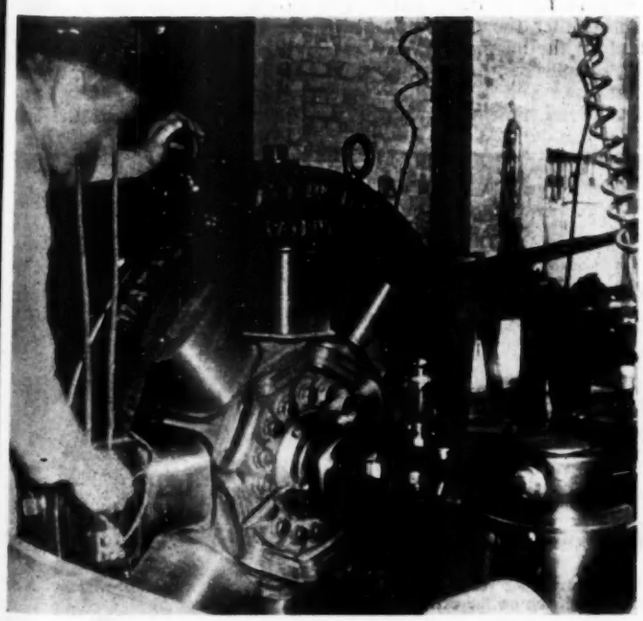
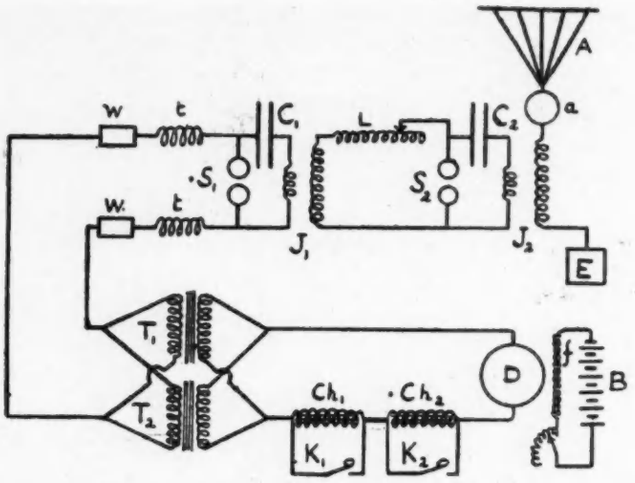


Fig. 1—The 2kV, 50 c/s alternator that provided power for the first spark transmitter at Poldhu



A—Aerial.
C_1–C_2—Condensers.
S_1–S_2—Spark balls.
J_1–J_2—Jiggers.
T_1–T_2—Step-up transformers.
Ch_1–Ch_2—Chokers.
K_1–K_2—Keys.
D—Alternator.
B—Storage battery.
E—Earth.

Fig. 2—A reproduction of the diagram showing the basic circuit of the Poldhu spark transmitter which was drawn for Sir Ambrose Fleming, the designer of the station

reliable means of measurement existed at the time and individual estimates made by those on the spot differ considerably.

With the encouraging news that Poldhu's signals were being strongly received at Crookhaven in Ireland, 225 miles away, Marconi, with two assistants—Kemp and Paget—took passage to St. John's, Newfoundland, the nearest landfall in the New World, taking with them large canvas kites and several small balloons with which Marconi proposed to raise the aerial. This method of aerial support avoided the public speculation that the erection of tall masts would bring, and saved time.

At St. John's all possible assistance was given to Marconi and his party by the Governor of Newfoundland, Sir Cavendish Boyle, and the Prime Minister, Sir Robert Bond. Six hundred feet up on the clifftop of Signal Hill, overlooking St. John's harbour, was the disused Barracks Hospital; a ground-floor room in this building was placed at Marconi's disposal and here he set up his instruments, some of which are seen in the heading illustration.

On December 9 a cable was sent to Poldhu instructing the engineers to begin transmissions on December 11, between 3 p.m. and 7 p.m. G.M.T. The signals were to consist of repetitions of three dots (the Morse letter "S"). This letter was chosen because—to quote Marconi himself—"the switching arrangements at Poldhu were not constructed at the time to withstand long periods of operation—especially if letters containing dashes were sent—without considerable wear and tear, and if S's were sent an automatic sender could be employed." Heavy gales were sweeping Newfoundland, however, and the next two days were spent in unsuccessful attempts to keep an aerial aloft. A balloon and a kite were lost in these endeavours.

On December 12 a full gale was still blowing, but despite this a kite was flown (Fig. 4) carrying an aerial to a height of 400ft. Marconi began a listening watch, using his latest syntonic receiver, but could receive no signals because the erratic movements of the kite were continually altering the angle of the aerial to earth, and therefore its capacity. He decided, therefore, to revert to the older, untuned receiver, using a telephone earpiece in series with the coherer.

Various types of coherer were tried, one of which was the so-called "Italian Navy" device. This is of particular technical interest in that it is described as consisting of a glass tube with a plug of iron at one end and another of carbon at the other, with a globule of mercury between them. The device was self-restoring and had to be used in conjunction with a telephone earpiece.

December 12, 1901, Marconi heard, faintly but distinctly, the groups of three dots which could only have been emanating from Poldhu, 2200 miles away. He passed the earpiece to Kemp, who confirmed that he had not been mistaken. Paget, to his lifelong regret, was ill on that day and was not present. The feat was all the more remarkable when it is remembered that the onus was almost entirely on the transmitter, for no amplification was possible at the receiver, and so the received signal itself had to be strong enough to operate the earpiece.

The use of a telephone in place of a recording tape and the absence of any unbiased witness had unfortunate consequences, for immediately the news was made public, a stormy controversy arose as to whether Marconi and Kemp had been deceived into misinterpreting the noise of static as Morse signals. Events conspired against Marconi in that the Anglo-American

Fig. 3—Part of the Poldhu transmitter, showing transformers in foreground, capacitors in wooden rack beyond, and one of the spark gaps on the extreme right

It would seem, therefore, that what is described as a coherer was in fact a true semiconductor rectifier with either the dissimilar plugs, or oxide film on the mercury, or possibly other surface impurities, performing the rectification process.

At 12.30 p.m., Newfoundland time, on

Telegraph Company, which had a message-carrying monopoly covering Newfoundland, threatened legal action if further experiments were carried out, and so there was no opportunity of giving a public demonstration. Two months later, however, tests were carried out between Poldhu and the liner

Fig. 4—Launching the kite which carried the receiving aerial at Signal Hill, Newfoundland. Marconi is on the extreme left, Kemp on the extreme right, and Paget in the centre

"Philadelphia" en route from Southampton to New York in which S's were received on the ship at a distance of 2099 miles and these were amply verified by witnesses. Ten months later—in December, 1902—two-way communication was effected between Poldhu and a new high-power transmitting station at Glace Bay, Canada—a circumstance made possible by the generous action of the Canadian Government in giving £16,000 towards the cost of the station.

There remained the problem of reconciling the theories of the scientists with the practical results achieved by Marconi. At that time no one knew of the existence in the upper atmosphere of an ionised layer which reflects radio waves and makes long-distance communication possible. In 1902 Heaviside in England and Kennelly in America independently postulated the existence of such a belt to account for Marconi's achievement, but its actual existence remained a matter for controversy until the 1920's.

There were, in fact, many unknowns at the time. Until the tests between Poldhu and the liner "Philadelphia" in February, 1902, it had not been realised that much longer ranges were obtainable at night. Indeed, only then was it appreciated that for the transatlantic experiment a listening watch had been kept at the worst possible time of day. Again, the success of the operation led to a universal acceptance of the rule "the lower the frequency, the greater the range" and it was not until 1924 that the value of the short waves for long distance communication was realised, largely as a result of the pioneering work of amateurs. The inauguration in 1924 of the Marconi-Franklin short-wave beam-radio service ushered in a completely new era in international radio communication.

There was a commercial radio station at Poldhu for thirty-four years, until the equipment was dismantled in 1937. It was here, too, that much of the experimental work in connection with short-wave beam transmisson took place. Poldhu radio to-day is commemorated by a granite column on the cliff overlooking Mounts Bay. All the Marconi company's property in the area has been presented to the National Trust. The link between the amateur radio movement and the development of commercial radio on the high frequencies has been symbolised during this week by the co-operation between the Radio Society of Great Britain and Newfoundland amateurs in maintaining schedules on the amateur bands between Poldhu and Signal Hill. During the period they received greetings from the Postmaster-General and the Chairman of Marconi's Wireless Telegraph Company Ltd.

Magnetohydrodynamics

At the Institution of Electrical Engineers, London, on Thursday, December 7, a Parsons Memorial Lecture was presented by Professor M. W. Thring. Professor Thring had prepared no written material and he spoke extempore from notes. We print below what he is reported to have said. The principles of magnetohydrodynamics can potentially be applied to the generation of electricity directly by passing a high velocity conductive gas jet through a magnetic field. Thermal efficienies up to 60 per cent should be realisable. Professor Thring discussed the problems involved and pleaded for a greater effort to be made in this country towards their solution.

I THINK that the choice of magnetohydrodynamics as the subject for a Parsons Memorial Lecture is a very suitable one. I have studied Parsons' work and have not found any that he did in this field. He did do some very interesting work on electrostatic effects in high-velocity steam jets and it might be said that that could be related to the alternative method of electricity generation, generating electricity by a jet carrying static electricity against a field, but I have not found anything on magnetohydrodynamics. He also did some very amusing work trying to make diamonds by firing rifle bullets with three times the normal charge so as to get very high temperatures when he stopped them, so that he was obviously interested in these things; but the good reason for a lecture in his name being given on this subject of magnetohydrodynamics is that he showed that the method of making power from steam which up to that date had been regarded as the right way of doing it, the piston engine, was not the right way, and that the turbine was a better way of doing it. I want to try to indicate in this lecture that even steam is not the right way of making electricity, which is going one step further on the path that Parsons started.

In this connection I have to confess frankly that I am talking about applied magnetohydrodynamics. The subject has been studied in many universities simply as a pure science subject in relation to what happens inside stars, where there are plasmas which are very good conductors moving round at great speed, generating enormous magnetic fields and currents and all kinds of amusing effects. I am interested in this subject from the practical point of view of whether or not we can make electric power from the combustion of fuels with a higher thermal efficiency than we can hope to get by means of steam. That is the object of the exercise.

In the case of magnetohydrodynamics, the master invention is one which has occurred to many people, the idea of generating electricity by making an electric conductor cut lines of force. What we propose to do is to use the working fluid in the thermodynamic cycle, to use the combustion products, at high temperature and high velocities, as the conductor which cuts the lines of force and generates electricity.

Here we have the master idea. I came across this myself about ten years ago, but I have since discovered that Karlowitz in America, with Westinghouse, was working on this before the second world war, and there were at least half-a-dozen patents on it before the second world war, so that the master idea has occurred to many people. Given the master idea, however, all the work which has been done on what happens inside stars suddenly begins to have applications, so that people go on doing fundamental work but now have one eye on the industrial process.

It is the same with Parson's work, where we find the same steps: the master idea, of the turbine, and the four stages of development to bring it to a practical industrial process. The first stage is completely fundamental applied science, studying the subject as a pure scientist does; the second, because there is or may be something useful in it, is to look at it from that point of view; the third is the pilot plant, where it is shown that the idea works; and finally there is the industrial process which is an economic proposition. These are the steps which have to be taken in any new process. The question which I want to ask is this: what are the difficulties and barriers in front of electricity generation by magnetohydrodynamics and how will they be overcome? I want to finish by suggesting ways in which they may in fact be overcome, I hope in this country.

What is Magnetohydrodynamics?

I must next define my terms and say what I mean by magnetohydrodynamics. It would be better to call it magnetic fluid dynamics, because it really refers to any system in which there are magnetic fields, some kind of fluid flowing and currents in the fluid. It is obviously possible to have the equivalent of a dynamo in this type of system, where we push the conductor by mechanical force through a magnetic field and generate electricity. That is a dynamo system. The simplest way to draw it is in the form of a box, with the flow of magnetic current and the magnetic field as two of the directions and the resulting voltage as the third, at right-angles, obeying the classical law that the volts per centimetre is the product of the magnetic field and the velocity multiplied by 10^{-8}. That is the simple system of the dynamo.

Equally, it is possible to have the magnetohydrodynamic system which is a motor. The obvious example is the electromagnetic pump, where we pass a current through mercury, flowing in a magnetic field, and it obeys the classical law, like any other conductor, that the force is the product of the magnetic field, the current and the length of the conductor in the magnetic field. We can have a magnetohydrodynamic motor or a magnetohydrodynamic dynamo. I propose to demonstrate both at the end of the lecture, when I hope to be able to generate approximately 0·05V and a very small fraction of an ampere by discharging a small toy rocket through a permanent magnet with water-cooled electrodes and to demonstrate the opposite case, the magnetohydrodynamic motor, by propelling a small ship by discharging the current between two electrodes. I have put some salt in the water to make it conduct reasonably and there are some strong permanent magnets in the boat, which will move when the current is switched on. We have, therefore, a very simple motor and a very simple dynamo and in each case the conductor is a fluid. In the motor we push the water back and so push the boat forward, which is the way in which a boat is propelled in any case.

The classical method of producing electrical energy is to burn fuel and produce heat (when we at once become subject to the second law of thermodynamics, with the T_1/T_2 limitation in efficiency) and use the heat to push turbine blades or a piston in a piston engine and produce mechanical work, and by means of a rotary dynamo produce electrical energy. We can also, of course, have the fuel cell, which does not go through heat at all and is not subject to the Carnot cycle of limitation of efficiency in any way. We can with magnetohydrodynamics go straight to electricity, without mechanical work or a rotating shaft. There is also the other method—no man yet has made a machine to do it, but we do it with our muscles—where we convert chemical energy into mechanical work without heat. There is also the reverse process, the electric motor going from electrical energy to mechanical work. We have also the thermionic diode for electricity generation from

heat, and the thermoelectric effect for electricity generation; but we are talking about the combustion-magnetohydrodynamic cycle.

I want to divide these processes that go via heat a little more in detail, because there are many different ways of classifying the thermodynamic or heat processes of producing power or electrical energy. For the moment I want to divide them according to the effect of the walls on the system. The President said that he thought that materials were the limitation on magnetohydrodynamics, but that is only partly true, and it is much less true than in the case of the turbine or the gas turbine or the other processes in which walls or blades or pistons play a much bigger rôle ; because in magnetohydrodynamics we are essentially generating power throughout the volume, and the bigger the system the smaller the surface of the wall in relation to the volume and, therefore, the smaller the material effects which are difficult.

If, therefore, we divide the processes in this way we can divide them into those where we generate the heat inside the working fluid and those where we have to push it through a wall. The latter are automatically limited by the fact that the wall has to be able to stand high temperatures and pressures, and this is usually a nuisance. Under the internal combustion processes we have the diesel cycle, the Otto cycle (with piston engines), and gas turbines, using blades, and the magnetohydrodynamic open-cycle process. Among those where the heat has to be pushed through a wall we have the classical steam cycle, the closed cycle gas turbine, and the closed-cycle magnetohydrodynamic system where the working fluid is pumped round and round a closed cycle and the heat has to be put in through a wall on the way round.

Scale Effects on Magnetohydrodynamics

What are the scale effects in magnetohydrodynamics? There are several of them. The effect of the very high temperature gas and the conduction of heat to the pole-pieces of the magnet will become less important with increase in size. Insulation is necessary to prevent the heat getting through. The fact that there is some voltage loss at the electrodes will be less important the bigger the system, so that again the scale effect is in favour of size. There are also the effects where the gas flow goes in and comes out, and again the longer the system the less important these effects are. All the scale effects in magnetohydrodynamics make a toy experiment such as I am going to conduct here very difficult. With a 500MW system we should have a huge space with a big magnet and very little walls, and it would be comparatively easy. If we have a velocity of, say, 10^5cm per second, which is about 3000ft per second, and if we have a magnetic field of 10,000 gauss, we shall get a voltage of about 10V per centimetre across the magnetic field in the gas flow, which is a reasonable amount of power to get out of it.

That may make it all sound too easy, as it is obvious that magnetohydrodynamics is not so easy as that as a method of electricity generation or it would have been used a long time ago. The main difficulty, which is obvious, is that the gas is such a poor conductor. There are other possibilities. For example, if the gas is conducting electricity as a result of free electrons the current will be carried by the free electrons, and they are the ones which are slowed down or braked by the current flow, and the ions will not be stopped, because the electrons are so much lighter. One answer is to try it and see, which is what the Americans have done. They find that it is possible to brake the gases in this way, and theoretically the answer is almost certainly that the electrons slow down the positive ions, which are heavy, by the coulomb force, the electrostatic attraction between these, and the positive ions transfer the force to the neutral material, which is the rest of the gas ; but we do not know much about it yet.

Gas Conductivity

The big problem is the gas conductivity. The total power internal and external which can be got out per unit volume of the magnetic field depends on the square of the magnetic field, the square of the gas velocity and the specific conductivity of the gas. If we put the units in we find that we need a gas conductivity to slow the gas down in a reasonable length of path which is of the order of 1 mho per centimetre or, which is the same thing, 100 mho per metre. It is possible to get away with one-tenth of that, but that is the order of σ needed to get a reasonable size engineering job if using a magnetic field of the order of 10,000 gauss and velocities of the order of 10^5 centimetres per second, which is about Mach 1, 2 or 3 in a gas flowing at high temperatures.

The problem is to get this gas conductivity. It is fairly clear that it has to be obtained by having a sufficient number of free electrons, because only the electrons have a high enough mobility to provide conductivity. When we work it out we find that we have to have one free electron to every 1000 neutral molecules, which is rather a lot. The classical method of doing this is obviously to put an alkali metal into the gas in a small percentage, say 1 per cent of potassium, sodium or caesium, and then rely on thermal ionisation of the alkali metal to provide the gas conductivity which is needed. This has been done. A plant has been run for two or three minutes in America putting in potassium and having combustion with pure oxygen and getting a very high temperature and sufficient gas conductivity to generate a reasonable amount of power per unit volume of the magnetic field. The basic difficulty with that type of system arises from the thermodynamic limitation on the process.

I shall now sketch very simply the ideal classical thermodynamic cycle for a process of this type. We have in effect a compressor where we take in atmospheric air and compress it to 5 to 10 atmospheres. We then have a heat exchanger where we heat it to as high a temperature as we can possibly get and then a combustion chamber where we inject fuel and burn it in the preheated compressed air. It then goes through a convergent-divergent nozzle, expanding it down to low pressure, get our Mach 3 velocity and then have our magnetic field and electrodes. We take the gas out, use it on the other side of the heat exchanger, and discharge it or run it through a waste-heat boiler. If we have expanded it to sub-atmospheric pressure we have to compress it back to atmospheric pressure again and discharge it.

The problem with that cycle is that we have an adiabatic nozzle which involves a temperature drop ; we have T_1 and T_2 at the two ends of the nozzle and the Carnot cycle efficiency of the process is $1-T_2/T_1$, so that ideally we should have a very high T_1 and a very low T_2 to get efficiency and also to get the very high velocity which we want. That means, however, a low T_2, which will in general be too low to give the thermal ionisation needed to ensure that the potassium, even with its low ionisation voltage, provides a sufficient number of free electrons to make the gas conductive. That is our problem. The simple thermodynamic cycle involves this essential difficulty of getting the gas to be a good enough conductor.

Possibilities

I now wish to suggest various ways in which I believe that this basic problem will be overcome, because I think that magnetohydrodynamics has reached the stage where the basic master invention has arrived. It is a very interesting cycle. It will have a very high T_1. It is not limited by walls or pistons or blades or pushing heat through walls. It has a very good upper working temperature. The trouble is that it is so difficult to make the gas a good conductor. The first type of solution for this problem is to have some way of making the gas a good conductor when it in fact is not at a very high temperature. It is possible that we could have some kind of chemical reaction going on in the gas as it goes through the magnetic field, giving a sufficient number of free electrons to make the system conducting. We do not need very many from the point of view of the overall thermodynamics. There is some evidence that certain compounds may be better than the straight elements in giving conductivity, but it is obvious that a great deal of quite fundamental applied science has to be done on this question of making a gas a good conductor for long enough to get the power out of it. The time for which it is necessary to keep it a good conductor is only of the order of 1 millisecond or so, but we must not have a gas which mops up the free electrons too fast. Combustion gases in an open cycle containing triatomic molecules are very good moppers-up of free electrons.

I should have said that the other application of this type of system would be to the case of nuclear fission. With nuclear fission it is possible to conceive some very interesting cycles. We can conceive a homogeneous gaseous reactor in which the thing becomes critical every time it gets into a large sphere and heats itself and goes out and goes on heating itself, producing a significant amount of ionisation as it expands through the nozzle but still acting as a good conductor as it passes through the magnetic field. There is obviously great room for research here, because one of the big limitations with a combustion system is that there is a limited temperature rise due to the combustion, so that if it is desired to get a higher T_1 than a certain amount, and therefore a higher T_2, it is necessary to use tremendously high preheats, which involves the difficulties of very high temperature heat exchangers.

The next possibility is that of running the system either with a very high T_1 by using very high preheat or pure oxygen for the combustion or, alternatively, having a system with a comparatively small expansion ratio and therefore a low Carnot cycle efficiency ; but the penalty there is a low velocity. We want $V^2 \times \sigma$, so that we can use a lower velocity, but as soon as we do so we must have a rather higher conductivity and there is the penalty that the cycle efficiency comes to only about 10 per cent, whereas the aim of this whole exercise should be to make the overall efficiency of the magnetohydrodynamic generation system of the order of 60 per cent, which is one-and-a-half times the best that can be hoped for with King Steam. This is the object of the exercise, and I do not think that the use of a very small temperature ratio is the right solution, but it is one possibility. It will mean having a waste-heat boiler,

because T_2 will still be very high, in the region of 2500 K, so that we shall need a waste-heat boiler to extract that heat and a full-size power station on the back of it giving 40 per cent efficiency, to which would be added this 10 per cent.

All the figures that I have given so far are based on a magnetic field of the order of 10,000 gauss. If we could go to 100,000 gauss we could afford to have one-hundredth of the gas conductivity, which would be very nice ; but, of course, 100,000 gauss is expensive. In America a design study project has been done for a large pulverised-coal-fired magnetohydrodynamic generator with water-cooled copper coils carrying fantastically heavy currents and cooled so that it is possible to get a field of this order without an iron core. The maximum which can be got with an iron core seems to be about 30,000 gauss. If we go higher we begin to get a very heavy power which is just resistance heating in the magnetic field coils. The Americans claim that what they are doing is worth while because of the scale effect which I mentioned earlier ; the system will be so big that we can afford a few megawatts in the magnet because we are getting hundreds of megawatts out of the system. Scale here is again in our favour.

Superconductors

Another method, which I think is fascinating, for getting a very high magnetic field is the use of superconductors. At first sight it seems absolute nonsense. Superconductors have to have temperatures near absolute zero, while the gases are away up at 2500 deg. Cent. or at least 2500 deg. K., so that it may be said that the two do not meet ; but this is not true. If we are going to insulate over 2000 deg. we may as well insulate over another 300 deg. or so, and again scale effect is in our favour. We can envisage an enormous circular coil, insulated, with superconductors inside it, and another underneath, and a fantastic magnetic field for almost no power at all because of the superconductor properties. We have not got to such high magnetic fields in superconductors yet, because they will not stand their own magnetic field ; but this is a very fascinating direction to take and is again a case where fundamental science has very interesting possible practical applications.

Generating Alternating Current

If we want to generate a.c. instead of d.c. with this system we run into all sorts of problems about rotating magnetic fields or running six of these to give pulses alternately to make a combination giving three-phase a.c. A modern design study to which I have already referred led to the conclusion that the capital cost of converting the d.c. into a.c. was higher than the capital cost of the magnetohydrodynamic generator, but the whole plant would still be cheaper than the present method of generating electricity so that if we can generate a.c., which is certainly feasible, we can get the capital cost down and have a big gain there. The reason is obvious : it is that we have not all the tubes and blades and so on to push the heat through or push the power against.

I now wish to mention a very interesting possibility that I think might be applied to solve the basic difficulty of gas conductivity. The problem here, as I have outlined it, is that the thermodynamic working fluid and the electrical conductor are the same fluid. That is obviously bad, because for the thermodynamic working fluid we want a very low T_2 and a reasonably high T_1 to give good thermodynamic efficiency and high velocities, but as a conductor we want quite a different fluid. We should prefer it not to have triatomic molecules in it, and if it is to carry an alkali metal, if we are going to ionise an alkali metal, we should prefer in particular to have it at a very high temperature. The suggestion, therefore, is a very simple one. Cannot we have a combustion chamber and inject a short pulse every so often of, say, pure oxygen and some fuel and perhaps have delayed combustion in that short pulse and so throw a layer of a different gas which is a good conductor in between the working fluid which is running over the thermodynamic optimum cycle ? We shall then have got back to our old conductor with insulation between the wires. This involves all kinds of problems of the stability of the layers and so on, but it is not out of the question at the very high flow velocities which we have here. Some fundamental fluid flow work is necessary to study the stability of these layers with this tremendous braking action on them, but there are possibilities of overcoming the difficulty.

Pulsating Combustion

Another point is that the thermodynamic cycle may be improved by the use of pulsating combustion. The German V1, the " doodle bug," was a perfect example of pulsating combustion. Roughly, the working principle is not to have large compression but to rely on the fact that combustion takes place more or less at a constant volume to give a pressure rise which gives an expansion force, so that the pressure rise due to combustion at constant volume is turned directly into velocity of the gases through a duct out at the back. There is the effect of a compressor and it is obtained by pulsating combustion. We go up at constant volume instead of constant pressure on the entropy diagram and go to a much higher pressure. If we can run a system of this kind with pulsating combustion we shall have at once a better thermodynamic cycle, because we shall not need to do much compression and may even get away without any at all. That, therefore, is an interesting possibility.

Perhaps the most interesting possibility of all, however, is the use of a shock tube as a magnetohydrodynamic generator. Let us first consider a free piston system in which we introduce an explosive combustible mixture and push the piston through a magnetic field, compressing the mixture at the other end and having an explosion which pushes it back again. I have a model here of this type of system which I shall demonstrate at the end of the lecture. In this we push an aluminium bar backwards and forwards through a magnetic field. We are not doing it by combustion because you would not like the noise, and also we have not managed to do it yet ! We do it by compressed air, but the principle is the same.

Now let us consider turning this into a magnetohydrodynamic system, for which we rub out the piston. Let us imagine that we have in the tube low-pressure gases and a high-pressure explosive mixture. We fire it and rupture the barrier. The shock wave runs along. It has a very high-temperature pressure wave in front of it which becomes a very good conductor. We push it through the magnetic field and get a pulse of current in the conducting layer. We take a little of the wave energy out by that current and then use the rest of the energy to compress the remainder of the mixture and bang it backwards again. It is not yet in a practical form, but it is very interesting and could possibly give us this 60 per cent efficiency in a very simple system generating power direct from a fuel. It is well worth considering, because there are no mechanical moving parts, except the valves, which present comparatively little difficulty.

I have mentioned the kind of things that we need to do to the simple magnetohydrodynamic cycle before we can achieve its practical realisation. That brings me to the last thing that I want to say, which is that the conclusion to which I come from all this work is that this magnetohydrodynamic story has some faint shadows of the design study for the final plant here, but they are nothing like the final plant that anybody will build. There is not much at that level yet. There is not much in terms of a pilot plant at the 1MW scale. There is a great deal of fundamental work to be done lower down on gas conductivity and other questions. We need an organised national effort to co-ordinate all this work and achieve a break-through in these directions. Nobody can say at the moment which system will work. What we really need is a team of people working at fundamental level on systems such as the rocket and magnetic field, pilot plant systems—there are two or three being built in the country now—and ultimately on design studies. There are very many problems at fundamental level and all the way up the scale. The only way to solve this problem is by sharing forces, so that with a rather limited effort we can achieve a break-through.

Technical Reports

Beating the Heat Barrier. By J. Taylor. A.R.C. Current Paper No. 545. H.M. Stationery Office. Price 5s. 6d.—A short survey is made of the characteristics of aerodynamic heating at supersonic speeds and of the properties of a typical aluminium alloy when exposed to increased temperatures for prolonged periods. With this information as a datum an estimate is made of the minimum combined weight of cooling and insulation required for an aluminium aircraft structure ; the study extends to $M = 10$, height of 250,000ft and a range of 5000 miles.

Permissible Working Stresses in Concrete and Reinforced Bars for Highway Bridges and Structures. Memorandum No. 785. H.M. Stationery Office. Price 6d.—The permissible working stresses in concrete and reinforcing bars for highway bridges and structures have recently been reviewed by a panel specially formed for the purpose by the bridges committee of the Road Research Board under the chairmanship of Sir William Glanville. The recommendations of the Panel which are incorporated in this report have been endorsed by the Road Research Board and accepted by the Ministry of Transport as applicable to designs which require the department's approval. The new provisions supersede the relevant sections of Memorandum 577 and permit the use of high-tensile steel reinforcement at stresses consistent with control on cracking, for which a formula is given.

Road Research Laboratory Technical Paper No. 50. An Analysis of the Cost of Road Improvement Schemes. By R. F. F. Dawson. H.M. Stationery Office. Price 1s. 9d.—The expenditure incurred in road improvements in 1958 averaged £1 1s. per square foot ; it was £1.68 in urban areas and £0.83 in rural districts. These figures, based on recent schemes for classified or trunk roads in England and Wales costing more than £10,000, are given in the report under notice here. The investigation was based on Ministry of Transport records relating to more than 200 schemes that were carried out between August and September, 1958, or completed in the previous four months. It related primarily to the building of new roads or the widening or realignment of existing ones.

It was found that land costs accounted for 20 per cent of the total cost in all urban schemes and for more than 50 per cent in one-eighth of them. For rural schemes the average land cost was 3·5 per cent and in only one-sixth of the schemes did it account for more than 5 per cent. New dual carriageways cost £512,000 per mile in urban areas and £256,000 in rural areas ; new single carriageways cost £116,000 per mile in urban areas and £70,000 in rural areas, while the cost of converting single carriageways to dual was £171,000 in urban areas and £84,000 in rural areas. These are average values and cover a wide variation in some of the costs. They are relevant to general studies but not to the evaluation of particular schemes, it is stated.

THE ENGINEER

REVIEW OF BOOKS

DECEMBER, 1961

INTRODUCTION TO THE DYNAMICS OF AUTOMATIC REGULATING OF ELECTRIC MACHINES

M. V. MEEROV (Translated by J. S. Shapiro)

Publisher : Butterworth and Co. (Publishers) Ltd. 1961. *Price* 100*s.*

THIS book, published by Butterworths in association with the Department of Industrial and Scientific Research, is a translation into English of a Russian work dealing with the analysis and synthesis of automatic regulating systems. It will be welcome to Western control engineers as an indication of the trend of Soviet thought on this important topic, though the time lag of five years before becoming available in English detracts somewhat from its usefulness in this respect.

In a short introduction the author gives his definition of automatic regulating systems. This includes both true regulators and servo-systems as sub-divisions, but in fact most of the practical examples discussed in the text are of the first class. Also in the introductory chapter are several pages dealing with the history of the development of the theory of automatic regulating in the U.S.S.R., beginning with " the well known inventor of the first steam engine," I. I. Polzunov, said to have devised the error-actuation principle, afterwards referred to as the Polzunov principle.

The text is divided into seventeen chapters, the first two of which deal in some detail with the basic properties and equations of motion of electrical machines, and magnetic, electronic and rotary amplifiers. Then follows an introduction to the Laplace transformation, including a small table of standard transforms. Brief mention is made of the *p*-multiplied transformation, but the unmodified form is used throughout.

Consideration is next given to the basic " links " which make up a control loop, and derivation of their transfer functions. These are then built up into block diagrams for simple systems, each link type being given a block symbol of a different shape. Chapter 5 introduces the characteristic equation and goes on to discuss stability criteria for linear systems. The Routh-Hurwitz method and a variant of the Nyquist criterion are dealt with at some length, followed by a criterion based on the complex plane frequency plot of the characteristic equation. This is called the Mikhailov criterion, after its Russian originator, and suffers from the same limitation as the Nyquist plot, in that the effect of varying parameters other than system gain cannot readily be seen.

This difficulty is overcome by the next criterion considered, known as the generalised criterion, or " Partition," in which one curve (the " D-partition ") only need be drawn to investigate the effect of variation of one chosen parameter on system stability. This, in common with previous methods, becomes computationally laborious for systems above third order. One minor criticism here—Figs. 66 and 67 could with advantage give values of ω on the D-partition boundaries. The chapter is completed by a selection of criteria for systems to have negative real roots and hence non-oscillatory transient response to step inputs.

The author then devotes a chapter to simple stabilising devices, including transient feedback by *R-C* circuit and transformer, with examples of stabilising applied to a thyratron voltage regulator and a tracking system. A lengthy discussion follows on the " quality " of regulating systems. In the course of this, quantitative criteria for assessing quality are introduced, both direct and indirect, and frequency response plotting is examined in some detail.

Chapter 8 deals with the plotting of transient response, first by direct solution of the characteristic equation and inverse Laplace transformation, and then by two approximate graphical methods, due to Bashkirov and Solodovnikov. The latter is the author of a book published in the Soviet Union in 1955, and subsequently translated into English, solely devoted to this topic.

Analysis of systems of order higher than third being very laborious, approximations are usually made in which small magnitude parameters are neglected. Chapter 9 presents an interesting examination of the effects on system stability of neglecting such parameters.

Next comes a short chapter on systems incorporating pure time lags, a criterion for assessing their stability being given. This is followed by two lengthy and informative chapters on the synthesis and practical design of regulating systems. The examples chosen have considerable importance in the industrial field, strip thickness control of a cold rolling mill, speed control of a d.c. motor, and voltage control of two alternators feeding a transmission line being dealt with in fair detail. Systems with intermittent action are discussed in Chapter 13, with special reference to one particular balanced-beam type of voltage regulator.

The remainder of the book is devoted to non-linear systems, proceeding by way of a short introduction to three chapters giving methods of analysis. The first is the usual treatment of the phase-plane method, the second deals with point mapping of surfaces, and the last gives Goldfarb's version of the describing function method. These chapters are rather brief, but give a good introduction to the methods mentioned.

A useful bibliography of 117 items, all Russian, and ranging from 1838 to 1954, appears at the end of the book, as well as a short list of English and American books, presumably added for the English translation, though none is later than 1954. There is also an adequate index.

Notable omissions are the inverse Nyquist plot, which has many advantages over the direct form, the logarithmic gain and phase versus frequency plot (Bode), and the root locus method, all of which can play a useful part in the analysis and synthesis of regulating systems. On the other hand, some of the methods and techniques given in the book are novel to the Western engineer, and might well prove to be useful tools. No mention is made of analogue computers. A minor inconsistency detracts slightly from the usefulness of some of the diagrams which lack any indication of the parameters represented by the axes, although the text usually makes this clear.

In summary then, although not suitable as a text book giving current Western practice, this book presents an interesting insight into Soviet techniques of analysis and design of regulating systems, and engineers, should find it rewarding and informative. Moreover, it is well presented and extremely easy to read, credit for which must go both to the translator and to the author.

H. BOXALL

[Reply Card No. 1313]

INTRODUCTION TO TRANSPORTATION ENGINEERING

WILLIAM W. HAY, B.S., M.S., Ph.D.

Publishers : John Wiley and Sons, Inc. 1961. *Price* 94*s.*

ON two counts it may have been with a sense of mischief that the editor invited me to review this book.* Firstly much of its 505-page bulk deals with the mere operation of transport : the title should be *An Introduction to Transportation Engineering " and Operation.*" In leaving out the last two words the author, himself an engineer of eminence, weakly allows the greater to include the less. He debases what I hold should be the zealously safeguarded name of engineering. Traffic " engineers " have forced the breach. Are transport operatives to follow them in ? If so it will soon be rare to find in an " engineer " a person assiduously educated for, and dedicated to, creative work that requires a thorough knowledge of the strength of materials, the theory of structures, and all the other subjects of the basic Part 1 of our Engineering Institutions' examination. This journal may have to become " The True Engineer " !

The other red rag, which flutters throughout the book, is possibly at its most vivid in the very opening table, which lists the output in ton-miles per man per day in various forms of transport. One railwayman, we learn, has an output of 80,000 ton-miles a day ; and a footnote assures us that this is only a modest statistical average for all U.S. railroads : the maximum could be 640,000 ton-miles a day ! That puts the claims of British Railways' propaganda department in the shade. Their standard piece on man-output, which was quoted by the then Minister of Transport in the House of Commons on December 11, 1958, only asserts that " two men can move in one train as much as 25,000 ton-miles of heavy freight every hour." The following week THE ENGINEER editorially deplored that the minister " had allowed himself to be taken in " by that sort of talk. Now, three years (and many letters) later, regular readers will prefer not to be treated to further samples of this book's meretricious statistical glorification of railways. But the anatomy of the book's bias may be of interest.

There is nothing unduly derogatory about the term bias ; on a bowling green the woods are round, very nearly. So with this book. Being only an introduction to the subject, historically and technically, it goes back to the very beginning, and its mass is predominantly round and fair, comprising facts and figures that are elementary—or introductory. How introductory can you get ? Try to beat this, occurring about halfway through the book, on the subject of river and canal transport : " their use can be realised only where waterways are available "; or this, " for a given horsepower one can have speed or haul a heavy load, but one cannot do both at once." In short, the book is essentially a primer. It is for the uninformed ; the informed will not endure the tedium of reading it ; it is thus a safe vehicle for a discreet piece of " blinding with technology."

In his preface the author invites the reader to believe that " technological utility " constitutes the missing link in transport studies : his concern is to reveal, and compare, the technological utility of the various forms of transport. This grand design, he does not explain, simply means looking at transport from the professional operator's point of view, almost never from that of the client or customer, and only rarely, and unenthusiastically, from that of the amateur, do-it-yourself practitioner : in a primer one has a wide choice of what to explain and what not to explain.

Undeniably railways possess to a high degree this property of technological utility ; and Mr. Hay, as an engineer with strong railway connections, is able to put the fact across impressively. He avoids looking into it just that little bit more deeply which would show that the virtues of railways are due to their having a horizontal, private right-of-way, and that these same virtues would descend upon another form of transport if it took over the right-of-way ; but such revelations, he could argue, are beyond the scope of a primer. It is not to be presumed, however, that he shirks awkward points ; within its scope the book is comprehensive enough. For instance, in the chapter on terminals, the turnround time for a railroad car in the the U.S.A. is given as ten to fourteen days, whereas highway trucks will arrive loaded in the morning and go out loaded again that night ; but somehow this is made to seem no more than a piece of hard luck on the railroad operator, largely due to the contrariness of shippers and consignees, not detracting from the splendid technological utility of railways.

In this way it is made easy for the unsuspecting reader to end up convinced that technological utility is the supreme consideration in transport, and that, within this field, railways hold pride of place. Defenders of this historic form of transport will cherish the book ; it provides them with all the arguments for holding back the motor age, which is in fact upon us, although the recognition it gains of Mr. Hay amounts to no more than a plaintive admission that " highway transportation has a hold on the American interest and fancy that is a little out of proportion to its technological advantages." It is self-interest, he should reflect, and something that has already proved to be less ephemeral than fancy ; these are powerful forces.

In conclusion it must be made clear that Mr. Hay writes almost purely of the U.S.A., where many railroads still manage to pay their way. In too short a chapter on " Costs of Service " he is thus able to refer to the evils of subsidisation in a manner not open to a British railwayman. And, for the benefit of those to whom transport has become a matter of politics rather than economics, he is able to affirm that " co-ordination has no value for its own sake. It should be utilised only when it makes a real contribution to overall economy and efficiency of movement."

T. I. LLOYD

[Reply Card No. 1351]

* *Touché* !—Ed. THE E.

TEXTURES IN METAL SHEETS

F. A. UNDERWOOD.

Publisher : Macdonald and Co. (Publishers), Ltd. *Price* 28*s.*

IN concentrating on this novel subject the author has produced a very readable and scholarly monograph of which he and those who have encouraged and helped him may justly feel proud. Those who originated the subject of the diffraction of X-rays by crystals would have been surprised at the way in which it has helped in the elucidation of problems involved in the fabrication of metals. Nevertheless the use of X-rays in this way can now be regarded as one of the greatest technological successes of X-ray diffraction.

Many metallurgists in plant control, and in fundamental research, have to study and control the " texture " of the metal, but that word, which appears in the title of this book, may require some explanation to other readers. When metal sheets are produced the deformations involved cause the grains of metal to lie with their crystallographic axes tending towards certain preferred orientations. In extreme cases successful rolling can be prevented if the preferred orientation, or " texture," of the sheet becomes too pronounced. It is unusual to find a completely random orientation of the crystal grains in fabricated metal products and the practical importance of the consequent anisotropy has led to many investigations since Wassermann surveyed the field in 1939. In seven pages at the end of his book the present author lists nearly 300 references in alphabetical order of their authors. It is on the basis of this compilation that the five chapters of this monograph have been written, and nine pages of carefully produced index help one to make the best use of it.

Fibre textures are met with in castings, deposited films, and wires, but in metal sheets, owing to the restriction imposed by rolling, planes of a certain crystallographic form tend to lie parallel to the rolling plane. Stereographic projections, termed pole figures, are used to describe sheet textures, but they are rather inadequate. No single experimental method suffices for all problems, but the reader of the second chapter should be able to decide which to adopt. After comparing the X-ray diffraction techniques for determining pole figures it is concluded that Geiger counter methods are superior to the older film methods, which are usually only qualitative.

This little octavo sized book of 148 pages deals with Preferred Orientation, Methods of Determining Pole Figures, Rolling Textures, Recrystallization Textures, and Anisotropy. Perhaps it is the last of these that will prove to be most interesting to engineers. That is because of the interesting phenomenon of " earing " that has been studied in many metals and alloys, notably in brass, copper and aluminium. When cups are pressed from circles cut from isotropic sheets of metal the brims are level ; pressed from anisotropic sheets the brims are undulating, " ears " appearing at positions that are usually symmetrical with respect to the rolling direction. Removal of these ears is costly — moreover the wall of the object is also made thinner where the ears

REVIEW OF BOOKS *(Continued)*

occur, and fractures take place during the forming operation. The problem is therefore of commercial importance, especially in the production of face-centred cubic metals and alloys.

Anisotropic expansion and growth in α-uranium have important consequences in reactor technology and for some applications it may be necessary to resort to alloying or thermal treatment to reduce these effects. Much well directed effort has been put into writing of this welcome book.

T. HENRY TURNER

[Reply Card No. 1489]

THE AMERICAN CIVIL ENGINEER: ORIGINS AND CONFLICT

DANIEL HOVEY CALHOUN.

Publisher: Massachusetts Institute of Technology.

Distributed by Oxford University Press. 1960. *Price* 44*s.*

THE word which has formed the principal title of this journal for more than a century is an outstanding example of an important word which has varied in meaning from time to time, and is still accepted in different senses in different countries. The only general tendency which can be noticed is the constant trend in the direction of specialisation, with the concomitant need for an adjectival qualification. As engineering developed almost exclusively as a military pursuit, the simple word came to denote the military engineer; Dr. Samuel Johnson in 1755 knew only the military engineer. In the latter part of the eighteenth century, the industrial revolution introduced engineering to industry and resulted in the development of the distinctive designation of civil engineer. From the outset, there is evidence of the struggle for the status of the profession, and divergence of opinion as to whether the word should be confined to those having specified professional qualifications, or should apply also to "ingenious workmen and artificers."

In the U.S.A. the need for civil engineers developed towards the end of the eighteenth century, and there were conflicting ideas about the most suitable professional qualifications, and also about the role of the engineer in industrial and public life. David Stevenson recorded in 1837 that indigenous American engineering was influenced by three main factors, namely, that labour in the U.S.A. was expensive, timber plentiful, and lines of communication had to be formed at as small a cost as possible through almost unexplored regions. In the second edition of his *Sketch of the Civil Engineering of North America*, published twenty-two years later, he confirmed that these conditions still applied.

The volume under review is a critical study of its subject, of a kind and in a form which is published far more frequently in the U.S.A. than in Great Britain. The form is that of an academic thesis, with all that this implies on the other side of the Atlantic. The bibliographical note occupies nineteen pages, and the annotations forty-five pages. The present reviewer dislikes annotations separated from the main text (as in this book) despite the growing frequency of the practice. Moreover, the use of a separate series of numbers for the respective chapters makes rapid reference almost an impossibility. The author is Research Fellow at the Center for the Study of the History of Liberty in America, Harvard University. Let it be said at once that he has conducted his researches comprehensively and presented the results exhaustively. The result is a mine of information, of value as a source book, but unlikely to appeal to the practical engineer for reading as a narrative.

Two kinds of sources form the basis of this study, namely, the published records of organisations that employed or trained engineers, and the unpublished papers of a few such organisations and of a few engineers. The author informs us that a satisfying aspect of investigation has been the fact that soundings into unpublished material have confirmed and amplified, but not substantially contradicted, the indications that published materials give. In essence, the book is designed to collate information about the rise of the American civil engineer, the sources of his training in the late eighteenth and early nineteenth centuries, his increasing specialisation, and the definition of his duties, responsibilities, and authority, and thus the emergence of his status. The author poses the question "should the men who were building canals, railroads, and bridges be practical craftsmen; gentlemen and entrepreneurs whose knowledge of engineering was incidental to their ambitions; or professionals imported from Europe?" This question may be asked in retrospect, but it is extraordinarily unlikely that it was considered in such form or terms at the period under consideration. The men who owned or directed canals and river improvements in the decade or so after 1785 were uncertain how to provide the necessary technical supervision of their projects. They accepted what was available to them, with varying success. The next important construction phase was from about 1816 to 1837, and in this civil engineering used the services of an increasing number of graduates from the U.S. Military Academy at West Point. It was far from being a preponderating influence, however, as may be seen from a tabular appendix to this book. Incidentally, the source of the table is a "machine tabulation of coded biographical data" from biographical registers of West Point. Mr. Calhoun has gathered and collated a vast amount of material—almost certainly all that is necessary for such a survey—but his method of presentation is that of the abstract academician. What he has to say is of great value to the civil engineer interested in the evolution of his profession in the New World. It lacks the terse precision of language to which the engineer is accustomed.

CHARLES E. LEE

[Reply Card No. 1490]

ANALYTIC GEOMETRY AND CALCULUS

L. J. ADAMS AND PAUL A. WHITE.

Publisher: Oxford University Press. 1961. *Price* 78*s.*

STUDENTS of applied science, during their earlier years, may be confused by the wide variance that can exist between the presentation of their lectures and the text books to which they are recommended. In mathematics this inherent difficulty has, in part, been overcome by certain of the academic staff of American universities, who have written their own mathematics text books to provide the student with a powerful supplement to the lectures. What may at first sight appear to people in this country to be an overpublication of text books is perhaps justifiable in America, where the student population is much larger than ours. The Russian system of publication, under which the Academy may "recommend" that certain books be adopted, although it produces cheaper books, is perhaps less desirable than western methods which, although leading to much repetition of knowledge, do at least present the reader with fresh approaches and a choice of author-style.

In the present book the authors, who are respectively Chairman, Department of Mathematics, Santa Monica College, and Professor of Mathematics, University of Southern California, have written in excellent style in presenting the well known basic principles of calculus and geometry, as well as some ideas that are perhaps less well known but of equal importance. The writers assume that the readers are acquainted with basic algebra and trigonometry.

Since most books that are written on mathematics cover much common ground, the reader may be more interested in the style and presentation of the book than in standard treatments. The length of this volume extends to over 900 pages, with nineteen chapters of text and diagrams that are clear and easy to follow. A feature of interest to the student is the inclusion of 4000 problems, many of which stress the application of theory to problems in applied science. It is interesting to note that calculus is introduced early on so that it may be used in analytic geometry at a later stage; the derivative is presented as the limit of a certain quotient while the definite integral is introduced as a limit of summation. To clarify the concept of the definite integral, a simple algebraic function is integrated between limits by summation of an algebraic series.

Throughout the reading of this book, students of applied science, many of whom are merely interested in the automatic solution of problems, will find that they are being led

beneath the surface of problems into the realm of the finer and more basic ideas of mathematical thinking, while at the same time keeping in view the practical application of mathematics. Throughout this book mathematical principles are clearly presented by means of definitions, illustrations and, in many cases, theorems and their proofs. Worked examples in each chapter demonstrate step by step the application of theory to practical problems. Differential calculus extends as far as the solution of second order equations by four methods, namely ; Operators, Undetermined Coefficients, Variation of Parameters and Laplace Transforms. Numerous methods of integration include, for example, completing the square, right triangle substitution, reduction methods, numerical approximation, integration by parts and by trigonometric substitution, and the application to parametric curves. In chapter 18, Green's theorem relating a line integral round a closed curve to a double integral is proved, in addition to the theorems of Pappus, and triple integrals in rectangular, cylindrical and spherical coordinates. The basic ideas in solid geometry are treated in the usual manner in Chapter 16, where also in this context the concept of the vector is introduced. Vector calculus is applied to curvature and curvilinear motion in Chapter 13.

A valuable addition to the material in some chapters is to be found in their examples, which frequently refer to certain equations and methods that are not included in the text, thus at least giving the reader a nodding acquaintance with them. For example, such topics mentioned include the Cauchy-Riemann equations, Picard's method, the Runge-Kutta method and Euler's theorem.

Chapter 17 deals with partial derivatives and includes the gradient and ∇ (del) operator, divergence and curl of a vector field, and the tangent line and normal plane to a space curve. It is surprising to find that complex numbers have been omitted from this book, since they are a useful tool to the engineer and physicist in calculus and other problems.

Chapter 9 mentions the cycloid in connection with the brachistrochrone or curve of least time, the discovery of which by the Bernoulli brothers led to the calculus of variations. Chapter 4 proves the Law of the Mean, which is one of the most widely used theorems in calculus, as well as Rolle's theorem which is used in the theoretical development of calculus. In Chapter 7 on the central conics, the authors discuss the translation and rotation of axes and the removal of the " xy " term from the general equation. The analysis of a conic through five points illustrates how the entire profile of an aeroplane may be described by six conics of the type determined by two tangents (and the points of tangency) and an extra point.

One of the most attractive features of this book is that its authors attack all topics from a fundamental point of view. Most formulae are proved from first principles and the treatment of algebraic functions is deeper than that to be found in many other works of a similar nature. The subject is presented in such a way as to build up the confidence of the student as well as a more mathematical appreciation of the solution of problems. The reader is called upon to delve more deeply than is usual under the surface of mathematics, and in doing so he becomes by far the wiser. To the practicing engineer or scientist wishing to become better acquainted with fundamentals, or to the maturing student of applied science, this book gives a " new look " to an old subject and Professor Adams and Professor White, together with the publishers, are to be congratulated on its excellent presentation.

C. L. KIRK

[Reply Card No. 1491]

JANE'S ALL THE WORLD'S AIRCRAFT, 1961—62

Compiled and edited by JOHN W. R. TAYLOR.

Publisher : Sampson Low, Marston and Co. Ltd.

1961. *Price* 105*s.*

IN all probability, more and more importance is attached by British readers to *All the World's Aircraft* as the amount of aeronautical activity abroad becomes both absolutely and relatively greater. (As an example, the foreign makes of supersonic manned aircraft outnumber the British by 20:1.) Hence it is alarming as well as amazing to read the assessment of the much respected editor of the significance of the aircraft that appeared for the first time at Tushino last July, which is that they appear advanced only because of the long intervals between Soviet Aviation Days compared to Farnborough displays. This, written after the 1961 S.B.A.C. Display, distinguished by the appearance of only a couple of light aircraft which were not included in 1959, is untenable; it completely disregards the major differences between the British and Soviet bombers, that the former are subsonic and unarmed and the latter supersonic and armed, so that " Firestreak " or an equivalent missile might, given good weather and sufficient dispersed bases, be effective against the one but not the other. The requirements for fighters and for air-to-ground missiles are therefore more difficult by a large order for the British equipment. However, the record, as distinct from the comment, on the new Soviet aircraft is outstandingly good—it will be recalled that it was Mr. Taylor who first observed that the air-to-surface missile carried by the " Bear " may well be a "Fitter" with a nose-cap on the intake—and the code-names attributed have been authenticated.

Apart from this important addition to published knowledge, there are, as always, a host of small rewards for the diligent reader ; the description of the Bristol 188 is unprecedentedly complete, there is a really useful picture of the BEAGLE-Wallis autogyro, and we came upon yet two more twin-jet executive aircraft, projected by Hamburger Flugzeugbau and La Hispano-Aviación.

This year's edition incorporates a number of modifications, in particular that the "United Kingdom" is placed between "Turkey" and the " United States of America" : the Commonwealth countries are no longer all together. The U.K. section is, perhaps inevitably, confused ; one wonders how many readers will look for the BAC-107 under " Hunting," and the BAC-111 under " British Aircraft Corporation." A welcome reform that is creeping in is to put individual designs in direct instead of inverse chronological order, which is highly desirable when much of the data is common to both and logically quoted only for the elder.

Another and more debatable alteration is a separate section for " Air Cushion Vehicles." Many of the machines classed as " Aeroplanes " have their performance qualified as in, or out of, ground effect, and one of the " air cushion " vehicles turns out to be a ram-wing of which it is remarked that it might be regarded as a low-flying fixed-wing aircraft—and, of course, there are the Avro " Avrocar " and the Boeing-Vertol study for a winged GETOL (ground effect take-off and landing) vehicle to insinuate that such a division is not only artificial but even an obstruction to classification.

A complaint we have made before is of *Jane's* somewhat inclusive use of the term " first flight "; one page that looks excitingly full proves to contain such items as : " Beagle-Auster A109 Airedale (2nd prototype) " and " Beagle-Auster A109 Airedale (Continental GO-300 engine)."A new artist is this year responsible for the three-view drawings ; those of the IA-38 (regular readers will be delighted to know that this tail-less cargo transport has at last flown) are contradicted by the photographs, and those of the Capital " Copter " (an autogyro, remarkably enough) by the text. There are errors—the Convair " Hustler " that averaged 1105 m.p.h. from New York to Paris was refuelled thrice, not twice, in the 5183 miles flown from Texas to France. And the editor is maintaining the " Believe It or Not " tradition of which we have given examples in the past—of one helicopter it is said that the centre of *gravity* of the blades is ahead of the centre of lift, so that airloads tend to reduce the angle of attack, and of another that the tips of the retreating blades do not approach their critical Mach number ; an engine with the general arrangement, stroke, and even crankcase of the Volkswagen is described as the " own design" of Heinz Pollman Fahrzeug-Motoren-und Flugmotorenbau, and a flat-six is termed " vertically opposed " when cocked up for helicopter installation ; the Rocketdyne engine for " Saturn " is quoted as using the usual propellants and igniting hypergolically, while the United Technology Corporation are credited with a solid propellant configuration combining a tapered flow area, to avoid erosive burning, with a constant thickness from inside to outside ; in describing the Bristol 188 reference is made in one sentence to de Havilland " Gyron Junior " jets and prolonged flight above 1500 m.p.h., and to the " Red Top " is attributed " collision course interception from any direction."

[Reply Card No. 1482]

RAILWAY ELECTRIFICATION AT INDUSTRIAL FREQUENCY

Proceedings of the British Railways Electrification Conference, 1960.

Publisher : The British Transport Commission, 222, *Marylebone Road, London, N.W.*1.

1961. *Price* 100*s.*

FOUR international meetings since the war have added copiously to the once somewhat sparse literature on electric railway traction. The first of these was the Convention on Electric Traction held by the Institution of Electrical Engineers in 1950, and it seems remarkable to-day that the proceedings

REVIEW OF BOOKS *(Continued)*

of a meeting held only a decade ago should have included no paper on the industrial frequency single-phase system. The matter was mentioned in one of the discussions, and the reply was made that " although the single-phase system in any form would not prove economic for the lines with dense traffic in Great Britain, it might open the way for extension of electrification on branch lines with light traffic . . ." Much more on this subject was forthcoming a year later, however, when the French National Railways held their first *Journées d'Information* on the system at Annecy. This was followed in 1955 by a similar meeting at Lille, held against the background of completion of the Valenciennes–Thionville electrification, soon afterwards extended to Lille in one direction and finally to Basle in the other. The fourth meeting of the series was the British Railways Electrification Conference of 1960, the proceedings of which have now been published.

The forty-two papers at the conference were divided among eight sections and together form a comprehensive account of British Railways practice in industrial frequency electrification at that time. Since the decision was taken to electrify on this system, so much advance has taken place in semiconductor power rectifiers that some of the locomotive and rolling stock equipments described may soon have to be regarded as transitional. Some of them are frankly so already, for the timetable of the electrification programme made it necessary to go ahead with certain multi-anode rectifiers of basically industrial form but modified for traction. Further, the policy of giving manufacturers a free hand in developing various forms of control system presumably means that at a not distant date there will be a thinning out of varieties. Two sections of the conference dealt with motive power, each opening with a general paper by British Railways engineers and continuing with papers on individual electrical equipments contributed by the builders. These individual papers vary somewhat in the quality and value of their diagrams. Some give full contactor sequence charts but others do not, and some views of bogies and their details are shown without the annotation necessary for easy understanding of the text. Diagrams and illustrations are grouped at the end of each paper, which is not the most convenient arrangement. No doubt the time factor prevented revising the layout adopted in the preprints issued to delegates, and may also have been the reason for lack of uniformity in style, lettering, and scale of reproduction of the drawings.

The motive power papers are followed by those on power supply, overhead line equipment, research for a.c. traction, and signalling and telecommunications. There are four papers at the beginning of the volume on the equipment and procedures for the system tests, in which many quantities recorded at fixed points and on moving trains during the normal operation of the railway are processed by computer. This ambitious programme, intended to provide information on system performance for designers and users of a comprehensiveness and with a speed not hitherto obtainable, has yet to attain its full value. An appendix to the proceedings refers to the troubles experienced with rolling stock on the Glasgow and North East London lines, but it is not stated whether data derived from system tests have been used in studying conditions which might cause further disturbances.

It is hard to avoid reading the papers with hindsight, and seeing in some of the statements a hint of defensiveness against criticisms to come. It is ingenious to say that the French experiment in 50 c/s traction established a substantial advance on the work in the United Kingdom because, being larger, it had greater momentum, but is this an adequate explanation ? It seems more likely that time was lost in adapting the system to the restrictive conditions of British Railways, and redirecting effort which only a short time before had been concentrated on 1500V d.c. traction by the 1951 report on Electrification of Railways. Furthermore, it is not quite fair to say that the transformers and rectifiers on motor coaches have no moving parts when the associated paraphernalia of cooling systems and thermostats are remembered. Semiconductors reduce the complication, but there has been a large investment in mercury-arc devices.

Considering the controversy which has attended the choice of the 50 c/s system in this country, the discussions contain little excitement. There was some skilful fencing but no all-in wrestling. If surprise was expressed at some apparent departure from the fundamental simplicity of a high-voltage a.c. system, such as the use of compound catenary or booster transformers, the implied thrust was parried with a compliment, or the critic was reminded that " the purpose of the conference was not to discuss the comparative merits of one system with another." The arguments will continue, of course, and as the electrification of British Railways at 50 c/s a.c. pursues its course these proceedings will provide the indispensable background for an informed appreciation of what has been done and a constructive approach to what lies ahead.

[Reply Card No. 1416]

COLD FORGING OF STEEL

Dr.-Ing. Heinz D. Feldmann. Translated from the German by A. M. Hayward.

Publisher : Hutchinson and Company (Publishers), Ltd., 178–202, *Great Portland Street, London, W.*1.

Price 40*s.*

COLD forging can be taken to include any extrusion, upsetting, preforming, indenting, drawing or coining operation which takes place at a temperature below that of recrystallization of the metal being forged. It thus covers a wide field, and even steel has been cold forged for twenty years or more, though it is of course the non-ferrous metals which have the longer history in this connection. But for a long time cold forging of steel was limited in application and little was known about it, partly because the applications were few and partly because some of them, being for military purposes, were deliberately concealed. There is now nothing secret about cold forging as a process, but there has been a real lack of reliable information simply because nobody gathered together what was known and published it in a single volume. This deficiency the present author set out to remedy, and the publication of his book is timely, as there is a growing interest in, and use of, the cold forging process for forming steel.

Cold forging of steel offers some attractive economic and technical advantages in comparison with the available alternative production methods. Compared with hot forging, for example, it provides better dimensional tolerances and surface finishes. Against casting it offers greater precision and better mechanical properties, and it can compete, in suitable circumstances, with sintering, deep drawing and spinning. Cold forging, however, is not something which can be undertaken lightly. Its successful use depends upon correct design of the product as well as the tools (it may be necessary, and economic, to re-design the product), and it needs certain minimum quantities to be economic—this latter, of course, it shares with many other production processes, but what constitutes an economic quantity of cold forgings depends on many factors ; the book gives some guidance in this matter. It stresses another point, too, which has no less force in many other spheres, and that is that the customer should always consult with the cold forger before finally fixing his design.

But if the final analysis is best made jointly by the forging manufacturer and the customer, there is a lot which a prospective user would like to know before he gets to the point of discussing final designs. This book will help him in his approach to the subject, which it covers in considerable detail. As a text-book it is admirable ; as a quick reference book it is much less so, for it has no index, and the table of contents, though fairly detailed, is no substitute for what a busy man always needs in a technical book—a good index.

[Reply Card No. 1218]

THE CARS IN MY LIFE

W. O. Bentley.

Publisher : Hutchinson and Co. (Publishers) Ltd.

1961. *Price* 25*s.*

IT might be thought that " W. O.", Bentley's autobiography, would perforce have covered the subject of this publication's title. In fact, the title of this book is that of the first chapter, which deals with those cars Bentley knew well, other than those which, for little more than a decade, were his life. The subject matter of this further volume is in fact far more varied than the title suggests, being drawn both from the environment in which his life was lived and from studies, design or otherwise, that he has made. Not Humberstall himself could accuse Bentley of being a radish, and in fact one could wish for more cross-reference between the two books ; for instance, in 1930 he could not associate himself with a valve gear incorporating push-rods, whereas to-day he would adopt push-rod o.h.v. for an oversquare four-cylinder one-litre engine, which in a four-seater car will need a very long life indeed in terms of engine revolutions. On the other hand, his abhorrence of attempts to cast the bores and the crankcase together is unabated. While his emphasis on the (bad) influence upon cars of the normal (good)

surface of British roads is by no means out-of-date, one wonders whether he has given due weight to another of the virtues of these roads, the prevalence of good adhesion, in his advocacy of front-engine design; a broad hint of the shortcomings of *traction avant* is offered by the need for a lock restrictor to allow chains to be fitted on the Lancia "Flavia."

From a man whose first attempt at motor-cycle sport yielded a gold medal in a London–Edinburgh Trial, whose first design of aero-engine succeeded resoundingly in the savagely demanded application of powering air superiority fighters, and whose first motor car has, to say the least, stood the test of time (remember that the Ford "Anglia" 105E has the same piston area, at 16¼ h.p. R.A.C.) and whose experience has extended from locomotives to hydroplane destroyers and from fleet maintenance to design studies, one expects to learn much, and indeed there are many observations that few others could make. As one example he considers 5000 miles a reasonable servicing interval for a modern mass-production car, but 800 miles creditable for a locomotive.

Bentley shows himself to be an acute observer and keen critic, not least of himself; writing before the appearance of the David Brown Lagonda "Rapide," he blames himself for not reviving the V-12 4½-litre Lagonda after the war, while rather more of his readers may benefit from another of his self-criticisms, that he never devoted enough time to investigating the designs of other people. He is a strong advocate of learning from the experience of others, having, for instance, adopted the Ford design of connecting rod with integral big end studs for his V-12, although he finds it hard to avoid mocking at the lengths to which Rolls-Royce Ltd. carries this policy. It is in this context that one must make the only complaint against the book; he makes criticisms of the Minister of Transport and the County Surveyor of Surrey for not improving roads more rapidly, for cluttering them with signs and so forth. It would, perhaps, be more to the point to criticise Parliament and the Treasury for refusing the Minister and county surveyors adequate money.

[Reply Card No. 1421]

FIELD THEORY FOR ENGINEERS

Parry Moon and Domina Eberle Spencer.

Publisher: D. Van Nostrand Company, Ltd.

1961. *Price* 96*s.*

THE subject matter of this interesting book would be known to most British engineers as Partial Differential Equations of Mathematical Physics; and because of this name would, in all probability, be dismissed as too abstract and of no practical value. However, this attitude could not be further from the truth, and the name *Field Theory for Engineers* is an indication that the methods of theoretical physics are being used, more and more, in engineering design work. The book is concerned essentially with the solution of the four equations:

$\nabla^2\phi=\alpha$ — Laplace's equation.

$\nabla^2\phi=K$ — Poisson's equation.

$\nabla^2\phi=\frac{1}{b^2}\frac{\partial\phi}{\partial t}$ — The diffusion equation.

$\nabla^2\phi=\frac{1}{c^2}\frac{\partial^2\phi}{\partial t^2}$ — The wave equation.

with the addition of an excellent chapter on the vector wave equation, derived from Maxwell's equations. These are the fundamental field equations which occur repeatedly in many branches of engineering (heat conduction, electro-dynamics, elasticity and acoustics, to name but a few). These fundamental equations are rarely used, since problems are often simplified until they can be handled by other means—a method of solution that rarely produces the optimum designs which are essential to technical and commercial success.

The book has been derived largely from lecture courses given by the joint authors, which while producing an eminently readable treatise on the subjects covered, lacks the formality normally found in English textbooks. A criticism is that, of the several methods of dealing with partial differential equations, four (numerical approximation, graphical, experimental and rubber sheet) are dealt with very briefly—two (functions of a complex variable and Laplace Transforms) are covered with a list of references only—while separation of variables, probably the most satisfying method of solution, is dealt with in great detail, the object of the author's efforts being to demonstrate the range and subtlety of problems that can be solved by the classical method of separation of variables.

Chapter 1 is a survey, stating the general problems and covering the methods of solution other than separation of variables. An appreciable amount of mathematical knowledge is required for solution of partial differential equations by the separation of variable technique, and this is spread throughout the book, the chapters being included as required. Chapter 2 covers the vector analysis required and defines the various types of field. Chapter 3 gives the theory for co-ordinate and equation transformation (elegantly dealt with by the use of tensor analysis). Chapter 5 covers the solution of the ordinary differential equations that occur when the variables are separated; these equations are always of Bocher type, the Legendre and Bessel equations being typical examples. Chapter 6 gives a brief coverage of orthogonal sets of functions, from which the solutions of the equations of Chapter 5 are synthesised. Chapter 11 derives the necessary and sufficient conditions for separation of variables to occur in a given co-ordinate system. Chapter 12 is devoted to the derivation of co-ordinate systems which can then be assessed against the requirements of Chapter 11 for separation.

Because it is the most easily handled, and the simplest, Laplace's equation is investigated with great thoroughness, chapters 4, 7, 8, 9, 10 and 13 being devoted, except for minor deviations, to its solutions in a variety of co-ordinate systems (from Cartesian to oblate spheroidal) with a range of boundary conditions. Solutions are given for a large number of actual problems, examples being the design of transmission grid insulators and steady state heat flow in a finite cylinder. The treatment of Poisson's, the diffusion and wave equations appears, when compared with that given to Laplace's equation, rather inadequate. But they are each rated as a chapter, in which they are clearly explained and solved. These equations are rather more interesting than Laplace's equation itself, due to the addition of a further independent variable. The final chapter is devoted to the vector wave equation, attention being focused on wave guides, and transverse electromagnetic waves.

A particularly useful feature of this work are the lists of references provided at the ends of each chapter, and this attention to detail is typical of this sound, knowledgeable and valuable textbook.

[Reply Card No. 1492]

CHOICE OF CAREERS No. 105

Iron and Steel

H.M. Stationery Office.

1961. *Price* 2*s.* 6*d.*

THIS booklet is one of a series intended primarily for boys of school-leaving age. It presents the principal iron and steel manufacturing processes in simple, non-technical language and outlines the types of work available, the facilities for training and further education and the prospects for advancement. The book is well illustrated and packs a lot of information into its fifty-two pages. Up to a point it is a good guide to the openings and prospects in the industry, not only for boys, but also for older people who know nothing of iron and steel. But in one respect it is dated. Anyone considering making his career in the industry should surely be told something of current and planned developments. Oxygen steelmaking and continuous casting, to quote only two examples of newer techniques, loom large in the industry's present and future plans. To the former the booklet gives only a brief mention (and that not very clear) and of the latter it says nothing. To read the booklet is to gain the impression (rightly), that the industry is large and complex and that there are many branches of it in which a career can be made. But there is no indication of how rapidly techniques are changing. In a developing industry it may well be that the best opportunities are to be found in the new and expanding fields. At least the fact that these developments are taking place is an indication that the industry is a dynamic one. Prospective employees ought to be told that.

[Reply Card No. 1437]

PRESTRESSED CONCRETE CYLINDRICAL TANKS

L. R. Creasy, M.I.C.E., M.I.Struct.E., B.Sc.(Eng.)

Contractors Record, Ltd., Lennox House, Norfolk Street, London, W.C.2.

1961. *Price* 35*s.*

THE publication of this excellent book will be welcomed by engineers concerned both with the design and construction of cylindrical tanks. After a general introduction and a chapter on "Materials and Stresses," a chapter on "Basic Expressions" provides various fundamental formulae giving the load effects in tank walls for various edge conditions. This is followed by a chapter giving the "Design Effects of Prestressing" for similar edge conditions. Here the author introduces what he terms the "Semi-Sliding Wall-Foot," whereby the sliding inwards of the tank walls during prestressing is limited to half the calculated value by stops. The following chapter, "Partial Fixity" deals at some length with the effect of lack of full fixity resulting from the base flexibility. The chapter on "Elastic and Plastic Reactions" (this title is not strictly accurate) deals with the stress interactions between the steel and concrete due to elastic and plastic deformation. Excellent chapters are provided on "Secondary Effects," "Friction" (of prestressing cables), and "Temperature Effects." Then follows a chapter on "Prestressing Systems" commonly used and "Construction Problems." Next there are chapters on "Joints and Jointing Materials," "Examples of Pinned and Sliding Wall Tanks," "Examples of Complex Structures" and "The Roof Structure." The author closes with a chapter on "Repairs to the Concrete Structure" (thereby showing commendable realism in this

subject) and a brief chapter on " Economics." Tables of various mathematical functions used in the formulae are provided, as are a short bibliography and an index.

On studying this not very large book (216 pages) one is struck at once by two admirable aspects. First, the large coverage of the subject ; secondly, the particularly concise and cogent nature of the text. This is clearly a good example of a book written by an engineer for engineers, and the author may be excused both for occasionally taking too much for granted and for the isolated proof-reading error and split infinitive. It would, however, have been helpful to provide appendices giving the basic derivations and assumptions for the numerous formulae quoted. These could well be added in future printings of the book.

Throughout the book, the author treats his subject in a practical manner. The book is well illustrated by clear sketches and photographs, though it would have been preferable had all the lettering of the former been carried out by stencil-lettering or letterpress, as is the case from page 142 onwards. Some aspects, e.g. buckling, merit rather more detailed treatment. Such criticisms as there may be are very minor and cannot significantly detract from the value of this book. Anyone interested in this subject will want this book in his library.

[Reply Card No. 1493]

THEORIE UND BERECHNUNG DER ROTATIONSSCHALEN

P. B. J. Gravina.

Publishers : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. *Berlin–Göttingen–Heidelberg.*

*Price DM.*43.50.

THE present tendency in civil engineering to proceed from one-dimensional to two-dimensional structural elements—for which the architectural parallel may be said to be the use of shapes derived from organic forms—has shown itself in a particularly striking manner in reinforced concrete design. The present work falls into three main sections : the theoretical basis of elastic two-dimensional structures ; the membrane theory of shell surfaces of revolution ; and the theory of flexure of such shells. In all cases the shells are assumed to be subjected to rotationally symmetrical loading. As the application of the exact theory can be rather laborious, approximate methods have been developed, in particular by Blumenthal and by Geckeler. These and examples of their application are discussed in full.

[Reply Card No. 1235]

FIRE ABOARD

By Frank Rushbrook.

Publisher : Technical Press, Ltd., 112, *Westbourne Grove, London, W.*2. *Price* 63*s.*

WRITTEN by an experienced professional fireman, this book clearly sets out the nature of the problem to be solved in the prevention and fighting of fires in ships at sea and in port, and in the port installations. An historical review of fire-fighting methods and brief accounts of earlier disasters lead up to a list of ships lost by fire since 1800 which serves to illustrate the magnitude of the problems and the dangers of ship fires. In the succeeding chapters the subject is examined more closely, and the author gives a critical appraisal of three major ship fires at sea, namely, " Morro Castle," " Empire Windrush " and " Seistan," together with the main points emerging from the formal investigations. Similar treatment is accorded to major disasters to ships in port, and deals with " Normandie," " Noronic," and " Empress of Canada." Brief accounts are included of a number of serious fires involving port installations, such as the Luckenbach Pier fire, the Bombay Docks explosion, and the Texas City disaster, and in each instance the main lessons to be learned are listed. Consideration is given to basic legislation and the International Convention for the Safety of Lives at Sea, 1948, and comparisons made between the British and American rules, followed by details of the " Working Party " report on fire prevention and fire-fighting in ships in port linked with the author's comments based on experience. The practical application of legislation is given thought, and there are descriptions of a wide variety of fire-fighting equipment touching upon : pumps, fire hose and nozzles, fire extinguishers, fire-fighting apparatus, including CO_2, gas extinguishing systems and alarm equipment. The question of the embodiment of fire-proofing in the design and construction of ships is next considered with reference to controls for watertight doors, &c., sprinkler systems, fire-resistant materials, and sub-division into fireproof zones and the provision of means of escape. Stress is laid upon the need for effective overall training of personnel and the author states certain basic principles to be observed in fighting fires in ships at sea and in port, including the question of maintaining stability. The need for standardisation of equipment is underlined, and the prevention and control of fires in docks is discussed. In the final chapter the various suggestions and recommendations are summarised and given due weight. The book provides all those engaged in shipping with useful information, and advice based upon a wealth of experience.

[Reply Card No. 1494]

AN INTRODUCTION TO SERVOMECHANISMS

F. L. Westwater, O.B.E., M.A.(Edin.), M.A.(Cantab.), A.M.I.E.E. and W. A. Waddell, B.Sc.(Glas.), A.M.I.E.E.

Publisher : The English Universities Press.

1961. *Price* 15*s.*

THE servo has become so familiar as to be in danger of being taken for granted. Others besides students will therefore find it profitable to read this book, which rapidly introduces the idea that although the servo mechanism takes its name from *servus*, a slave, there are many problems in the attainment of a device whose output slavishly follows the input. After examining the errors that may arise, the authors proceed to the mathematics essential to their understanding and correction. Part 2 deals with servomechanism theory by means of frequency response methods, using mainly a graphical approach. All these chapters deal with angular position control, but the book concludes with a wider view of the variety of servo systems and a description of typical components for electrical position control. These include synchros, electronic and magnetic amplifiers, and torque motors for d.c. and a.c. Building on a sound foundation of well-chosen examples selected for their familiarity or ease of appreciation, the book provides lucid and logically developed guidance through the complexities of its subject.

[Reply Card No. 1369]

Books Received

Electrical Principles. Third Edition. By H. Cotton. Cleaver Hume Press, Ltd. Price 15s.

Marine Steam Boilers. Second Edition. By J. H. Milton. George Newnes Ltd. Price 45s.

Directory of Railway Officials and Yearbook, 1961–1962. Tothill Press Ltd. Price 60s.

Simple Applied Mathematics. By D. Hunt, 22, Park Road, Coventry. No price given.

Palmer's Private Companies. Forty-second Edition. Edited by T. E. Cain. Stevens and Sons Ltd. Price 15s.

Palmer's Company Guide. Thirty-seventh Edition. Edited by T. E. Cain. Stevens and Sons Ltd. Price 21s.

Design of Machine Elements. Third Edition. By M. F. Spotts. Prentice-Hall International Inc. Price 57s. 6d.

Motion and Time Study Applications. Fourth Edition. By Ralph M. Barnes. John Wiley and Sons Ltd. Price 28s.

Radio and Electronic Laboratory Handbook. Seventh Edition. By M. G. Scroggie. Iliffe Books Ltd. Price 55s.

Water Treatment for Industrial and Other Uses. By Eskell Nordell. Reinhold Publishing Corporation. Price 96s.

Tables Numeriques de Fonctions Elementaires. By J. Laborde. Dunod, 92, Rue Bonaparte, Paris, 6e. Price NF. 12.00.

Lehrbriefe für Kältetechnik. Nos. 26–30. General Editor H. Weimar. Verlag C. F. Müller, Karlsruhe. Price DM. 9.20.

Marine Steam Engines and Turbines. Second Edition. By W. J. Fox and S. C. McBirnie. George Newnes Ltd. Price 50s.

Der Vorrichtungsbau. Seventh Edition. By Heinrich Mauri. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM. 4.50.

Introduction to Deep Foundations and Sheet Piling. By Donovan H. Lee. Concrete Publications Ltd., 14, Dartmouth Street, London, S.W.1. Price 20s.

Calculus. Second edition, 1961. By George B. Thomas, Jnr. Addison-Wesley Publishing Company Inc., 10-15, Chitty Street, London, W.1. Price 49s.

Reactors. Volume 2 *in Progress in Nuclear Energy, Series II*. Edited by H. R. McK. Hyder. Pergamon Press, Headington Hill Hall, Oxford. Price 105s.

Directory of Members. Published by the Reinforced Concrete Association, 94/98, Petty France, London, S.W.1., 1961. (Correct to 1st May, 1961.)

Numerical Methods in Engineering. Second Edition. By Mario G. Salvadori and Melvin L. Baron. Prentice-Hall International Inc. Price 50s.

Calculus of Finite Differences. Second Edition. By Charles Jordan. Chelsea Publishing Co., 50, E. Fordham Rd., New York, 68. Price 6.00 dollars.

Combustion Engineers' Handbook. By L. J. Fischer. London : George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Price 30s.

Engineering Drawing and Geometry. Second Edition, 1961. By Randolph P. Hoelscher and Clifford H. Springer. John Wiley and Sons Inc. Price 72s.

Lectures on the Calculus of Variations. Second Edition. By Oskar Bolza. Chelsea Publishing Co., 50, E. Fordham Rd., New York, 68. Price 1.19 dollars.

Western Europe, Facts on a Market of 350,000,000 *People*. 5th. Edition. British Market Research Bureau, Ltd., 47, Upper Grosvenor St., London, W.1. Price 30s.

Safety and Health in Industry. 1961 Edition. Available from The Industrial Health and Safety Centre, 97, Horseferry Road, Westminster, London, S.W.1. Gratis.

Axial- und Radial-Kompressoren. Second revised Edition. By B. Eckert and E. Schnell. Berlin-Gottingen-Heidelberg : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.89.

Personen-und Güterbahnhöfe. Second revised edition. By O. Blum and K. Leibbrand. Berlin-Gottingen-Heidelberg : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.33.

Practical Steel Column. Revised Edition, 1961. By George D. Mouat, B.Sc., Draughtsman's and Allied Technicians' Assoc., Onslow Hall, Little Green, Richmond, Surrey. Price 3s. 6d. (2s. to Members).

Metallstatistik 1950–59. Statistische Zusammenstellungen über Aluminium, Blei, Kupfer, Zink, Zinn, Kadmium, Magnesium, Nickel, Quecksilber und Silber. Frankfurt am Main : Metallgesellschaft Aktiengesellschaft, Frankfurt am Main, Reuterweg 14. Free.

Electrical Aspects of Hunterston Nuclear Generating Station

A paper presented by J. Henderson, G. F. Kennedy† and K. J. Wootton‡, at a meeting of the Institution of Electrical Engineers in London on December 13 surveyed the electrical engineering aspects of Hunterston nuclear generating station. The subject matter included the overall station-control system and the auxiliary supply system with special reference to the arrangements for essential supplies. The d.c. drives for the gas circulators were considered in some detail. A short description was given of the starting-up procedure and operation of the station. Reactor instrumentation and control equipment were not dealt with. Excerpts from the paper are given below.*

HUNTERSTON is the largest of the first three civil nuclear generating stations for which construction authorisation was given in 1956. The station, which was described at Geneva in 1958,[1] will have a guaranteed net electrical output of 300MW, and comprises two reactors of the graphite-moderated gas-cooled type with natural-uranium fuel clad in magnesium-alloy containers. Each fuel element is individually supported by a graphite cylinder or sleeve so that elements in a channel are not directly in contact with one another. The weight of the elements is carried through the graphite sleeves to the steel grid which supports the whole reactor core. The reactor design is unique in that the machinery which charges and discharges the fuel while the reactor is on load is situated below the reactor. This arrangement permits the charge machine to handle half the elements in a channel simultaneously, rather than individually as in a top-charge machine. A second machine, known as the service machine, operating from above the reactor core, is used primarily for carrying out routine maintenance of control-rod drives, but can also handle individual fuel elements when required and carry out other maintenance tasks in the reactor. Thus, by the use of both charge and service machines, access to both ends of every fuel channel can be obtained.

System Design and Operation

The proposed transmission arrangements lend themselves to development to meet future requirements. For example, the site at Hunterston is capable of accommodating a further nuclear generating station, and such a development may be required by about 1970. In this eventuality, the second double-circuit line could be extended to Neilston or to another suitable point on the system, and the voltage of two or all of these circuits could be raised to 275kV. If all the lines were uprated to 275kV, the firm transmission capacity would be sufficient to carry the output from an additional station having a capacity of 1000MW.

Since the running cost will be lower than at any coal-burning station, Hunterston will be operated at the highest load factor. It is hoped that eventually an annual load factor higher than 80 per cent will be obtained, limited only by the availability of the plant. A pumped-storage installation having an aggregate capacity of 400MW is being constructed by the North of Scotland Hydro-Electric Board on Ben Cruachan (Loch Awe) for completion in 1965 or 1966. It is not anticipated that it will be necessary to curtail output at Hunterston because of low system requirements at night and weekends, with the exception that, during the two initial years, until the pumped-storage scheme is in operation, there may have to be some slight occasional reductions during the summer months.

In a conventional generating station, the turbines are provided with governors which automatically increase the steam input if the speed decreases, and vice versa. The Chapelcross and Calder Hall reactors were designed to run at a fixed thermal output determined by the operator, and the associated turbines are controlled by pressure governing, i.e. the turbine output is automatically controlled by the governor gear so as to maintain a constant steam pressure before the turbine throttle valve. The output of these stations is therefore not automatically adjusted in such a way as to contribute to the maintenance of stable system frequency.

A large part of the minimum summer night load in South Scotland will be supplied from Hunterston and Chapelcross, and if pressure governing were adopted at Hunterston, frequency stability would depend on a relatively small number of lightly loaded conventional stations, including spinning reserve capacity, together with the tie-line to the C.E.G.B. system. It was considered desirable, therefore, to investigate the possibility of controlling Hunterston in such a manner as to be in some degree sensitive to variation of system frequency, so as to assist in maintaining stable frequency, and such a scheme was eventually adopted.

Station Control System

Reactor Flexibility.—The steam-drum capacity at Hunterston acts as a buffer so that the reactor is unaffected by short-duration changes in steam demand. This characteristic would allow the turbine to follow rapid fluctuations of output demand if required by a frequency-sensitive governing system, without necessitating corresponding control action on the reactor, provided that the average output demand remained constant.

The ability to vary the power output of the turbines in response to sustained changes of system frequency depends, however, on several factors concerned with the design of the reactor.

(*a*) Reactor safety. If, under fault conditions, a reduction of coolant flow occurs without a corresponding decrease in reactor power, then overheating of the fuel will be experienced. To limit the amplitude of the temperature transient, the circulator control system has been designed to allow a maximum rate of change of coolant flow of 3 per cent per minute. This value determines the rate at which the reactor could follow a change in system demand.

(*b*) Temperature cycling. A change of reactor power causes variations of temperature in the fuel elements while the new conditions are being established ; owing to metallurgical effects induced by temperature cycling, frequent power changes could lead to damage to the fuel or its sheath and thereby to some reduction in fuel life. This effect is most significant for those elements within fuel channels adjacent to the control rods which would be moved during the power changes. In the design of the overall station-control system, this fuel-element temperature-cycling factor is important in determining the degree to which the reactor can follow changes in system demand.

(*c*) Xenon poisoning is the effect produced by the absorption of neutrons by the fission product xenon-135. Following a reduction of reactor power, a temporary increase of xenon concentration occurs. If the fall in power is sufficiently large, owing, say, to the tripping of a turbine, the subsequent increase of xenon poisoning may be sufficient to shut the reactor down. At Hunterston, xenon override has been provided in the form of removable flattening, so that, even following a reactor trip, it would be possible to be on load again in 13 hours limited only by the rate of withdrawal of control rods.

(*d*) Temperature differentials within the metal of the pressure-vessel sphere and core support grid may cause stresses which set a limit to rates of change of temperature. In practice, while the limits may be very significant during reactor start-up, they are not expected to be significant when thermal equilibrium is reached.

Overall Control System.—The two reactors at Hunterston are each associated with eight steam-raising units. Steam is generated at two pressures (578 lb per square inch at 385 deg. Cent., and 147 lb per square inch at 363 deg. Cent.). The steam receivers in each half of the station are arranged to be operated in parallel if necessary.

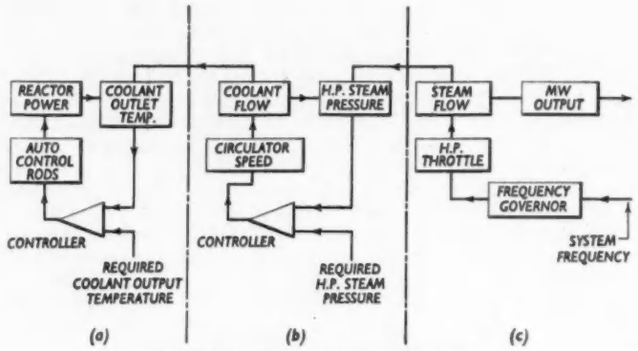
Each reactor and the three associated 60MW turbines are automatically controlled as a unit by the arrangements shown schematically in Fig. 1 and diagrammatically in Fig. 2. There are two independent systems controlling respectively the outlet coolant temperature (by control-rod movement) and the high-pressure steam pressure (by speed variation of the circulators). Superimposed overall is the characteristic of the turbine governing gear.

Turbine Governor System.—The turbines are equipped with both pressure-sensitive and speed-sensitive regulators—the former closing the throttle valves on falling steam pressure and the latter closing them on rising speed. Either regulator may be used by itself, or if desired, a mixed characteristic may be obtained by using both together.

Each turbine has separate pressure-sensitive controllers for the high-pressure and low-pressure steam throttle valves respectively, and these are set to maintain a desired steam pressure before the appropriate throttle valve. The use of these controllers causes the turbine output to follow the reactor power.

Each turbine has also one speed-sensitive governing device of conventional type common to both the high- and low-pressure throttle valves. When operated on speed governing, i.e. frequency-sensitive operation, high-pressure steam flow is controlled by the speed governor, the pressure governor being out of action. The low-pressure steam flow will, however, be pressure-governed in order to maintain control over the the reactor coolant-gas inlet temperature. Pressure governing is retained with changing load until the power output falls to about 50 per cent of the full load. At this point the maximum low-pressure steam demand defined by the speed governor gear falls below that necessary to maintain constant pressure in the low-pressure system, and frequency governing takes over from pressure governing in this system. The overall effective governor characteristic for the Hunterston turbines is

* South of Scotland Electricity Board.
† Partner, Messrs. Kennedy and Donkin.
‡ The General Electric Company Ltd.



(*a*) Coolant-outlet-temperature control system.
(*b*) High-pressure-steam pressure control system.
(*c*) Frequency-sensitivity turbine governor system.

Fig. 1—Block schematic of overall station-control system

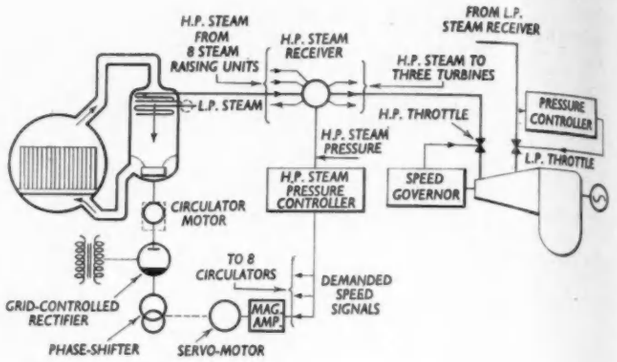


Fig. 2—Diagrammatic arrangement of overall control system

shown in Fig. 3. The average slope of the characteristic is such that an increase in frequency of 4 per cent (i.e. 2 c/s) causes the turbine to throw off full load. At high loads, however, the slope of the characteristic is such that the rate of throwing off load is about one-quarter of the average. The form of this characteristic means that the changes in reactor power and electrical output as a result of small changes in system frequency are not very significant near maximum load.

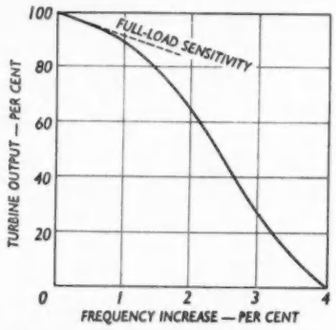


Fig. 3—Overall governor characteristic

Coolant-Flow Control System.—As in the automatic control of conventional generating plant, the control equipment maintains a constant steam pressure at the steam receiver (in this case the high-pressure steam only). A transducer measures the pressure in the receiver and compares it with the demanded value of steam pressure. Any small difference is amplified and fed to all gas circulators as a speed signal. The signal is modified within the controller by the addition of two components, one proportional to the rate of change of pressure and the other proportional to the product of the error and the time it has persisted. These components improve the response of the control system. It may be

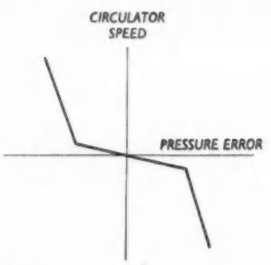


Fig. 4—Overall steam-pressure controller characteristic

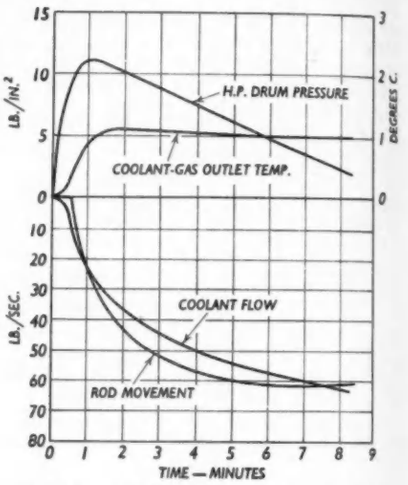
noted that there is no control signal derived from steam flow as is common practice on conventional plant. This is rendered unnecessary by the large capacity of the steam drums, and in any case it is undesirable for the reactor coolant flow and power to be sensitive to all small variations in steam demand.

In order that a speedy response to large variations of a steam demand may be obtained a second controller of considerably greater gain is used which acts only for steam-pressure differences greater than about 15 lb per square inch. This higher-gain characteristic will, for instance, minimise the amount of steam lost via the safety valves following the trip of one turbine before the reactor power generation can be brought down to the new lower level. The overall characteristic of the two controllers, therefore, has the form indicated in Fig. 4.

The gas-coolant circulators at Hunterston are driven by d.c. motors supplied from grid-controlled mercury-arc rectifiers. Speed variation is obtained by the movement of a phase-shifter by an a.c. servo-motor. Further speed increase may be obtained above the normal full-speed value by means of field weakening. The control circuits for the circulator motors, which are described below, automatically maintain the speed of each circulator at a value determined by the demanded-speed signal derived from the high-pressure-steam initiating device. As stated above the system is designed to limit the rate of change of circulator speed to 3 per cent per minute for reasons of safety.

Reactor Outlet Temperature Control System.—The reactor outlet-temperature control system maintains a constant outlet temperature of the gas from the central and each of the eight radial sectors into which the reactor core is divided. The temperature of the gas leaving a number of fuel channels in each sector is measured by thermocouples located at the channel outlets, and the average is compared with a predetermined value. A local change of power production in any sector causing a change in gas outlet temperature produces a difference signal, which, when exceeding a selected limit, drives the particular sector control rods in such a direction as to maintain constant power and so return the gas outlet temperature to the predetermined value. The control system also maintains a constant gas outlet temperature following any variation in coolant flow associated with a change in system demand or circulator fault conditions. The operation of the control rods has already been discussed.[2]

Performance of the Overall System.—Computer studies have been carried out to determined the performance of the overall station control system, the results of which indicate that under normal conditions of operation the control system will be stable and will satisfactorily maintain constant pressure in the high-pressure steam receivers following fluctuations of system frequency. As an example, the response of the system to a step change of system frequency of 0·1 c/s, assuming that the slope of the governor characteristic is equal to the mean value, is shown in Fig. 5. These curves



A linear 4 per cent generator characteristic is assumed.

Fig. 5—Transient response to 0·1 c/s increase in system frequency

show a sharp increase of steam pressure of about 10 lb. per square inch occurring within the first 1 to 1½ minutes. This is rapidly corrected by the change of coolant flow and reactor power, equilibrium being reached with reduced coolant flow within 10 to 15 minutes. The slope of the governor characteristic, however, is such that when operating at full load the transients arising will be about one-quarter of those calculated, but at half load they will be twice as great.

Auxiliary System

Some of the special requirements of the auxiliary electrical system for a nuclear generating station have been discussed elsewhere.[3] One of the main factors which influenced the design of the 6·6kV auxiliary system at Hunterston was the magnitude of the auxiliary load. Owing to the fact that the very large gas circulators are electrically driven, the total auxiliary load is about 15 per cent of the net generated output, compared with 4 to 7 per cent, which is more usual for an oil- or coal-burning station.

It is desirable to maintain forced cooling of the reactor at all times, even in the shut-down condition, because of the continued generation of heat by fission-product decay. Owing to their size, the gas circulators could not be duplicated, but arrangements have been made for them to be driven from a reserve source of power if their main supply

fails. The reserve supply must be completely independent and reliable, and a battery backed by diesel-alternators has been provided. In addition, the integrity of the control circuits for these circulators must match that of the power circuits. There must also be adequate standby for the auxiliary drives serving the circulators and other essential services.

Because of the serious consequences of a nuclear accident, protective gear and safety equipment have been provided on a generous scale. These are designed to "fail safe," and in accordance with this principle loss of supply to vital circuits will shut down the reactor.

Spurious trips are harmful to the reactor because they cause thermal shock to the fuel and possibly the structure. They are also expensive because a reactor once shut down takes some hours to restart. Inadvertent tripping of the reactor as the result of voltage disturbance must therefore be avoided by all means consistent with correct operation of the safety circuits.

Main Electrical Distribution System.—To ensure continuity of auxiliary supply a system of "unit" and "station" boards at 6·6kV has been adopted. There are two station boards supplied from two 20MVA 132/6·6kV station transformers, and six unit boards each supplied individually from six 8MVA transformers, known as unit transformers, connected directly to the terminals of the generators. In the unit-transformer arrangement, there is one stage only of transformation from the generator to the auxiliary busbars, whereas double transformation would have been involved if all the auxiliary load had been derived from the transformers connected to the 132kV switchgear. The 6·6kV fault level has been limited to 350MVA. Each of the station boards is divided into two sections by section switches, and there is an interconnector between those sections to which station transformers are not connected. The interconnector is normally open.

Each of the unit boards is also divided into two sections by section switches, and there are interconnectors between the station board and those sections of the unit boards to which unit transformers are not connected. These interconnectors are normally open. In order to ensure continuity of supply, a "quick-switching" scheme has been adopted. If the normal supply from a unit transformer is lost, a supply from a station board is automatically switched in after a time delay. The scheme is considerably cheaper than supplying the auxiliaries entirely from station transformers or from station and unit transformers permanently in parallel. This method of maintaining supply is believed to be unique in this country in its application to a major power station, although it is used in various forms at several oil refineries and is widely adopted in the United States.

The two requirements for the operation of the scheme are that the unit-transformer switch has opened and the unit-board busbar voltage has dropped to 25 per cent. This is the residual voltage produced as the induction motors slow down, and the feature is provided to minimise the electro-mechanical shock to the motors when they are re-energised from the new source of supply. The protective gear is arranged to prevent the alternative supply being closed on to a fault. This is achieved by discrimination between the unit-board busbar section protection and the unit-transformer 6·6kV protection, the former operating faster than the latter.

Where possible the important auxiliaries are fed from unit boards rather than station boards. Thus the six circulating-water pumps, which provide a common station cooling-water system, are conveniently distributed one to each unit board; the turbine-hall auxiliaries are distributed similarly. The six normally running high-pressure feed pumps and six low-pressure feed pumps are arranged in like manner, while the standby feed pumps go logically on to the station boards. The eight circulators for each reactor, however, are connected one to each section of the three unit boards and one to each of the two station boards. Under normal switching conditions, the 132kV busbar-section switch will be closed, the 6·6kV busbar-section switches will be closed and the station-board interconnector open. With the exception of the circulator drive, therefore, the complete system is divided into two halves comprising one reactor and three generators. Normally there is no interconnection between these halves at the 415V level.

The arrangement of the 415V switchgear, with a maximum fault level of 25MVA, is conventional, following the unit principle wherever possible. There is, however, much duplication of supplies, sectionalising of busbars and two out of three alternative supply interlocks.

The most important consequences which follow from the system layout [described in the paper] are as follows.

(*a*) During normal running, the bulk of the auxiliary load is fed from the unit transformers. When a generator is out of service the associated auxiliaries are transferred to the station transformers.

(*b*) If a unit-transformer circuit-breaker opens, an alternative supply to the unit board is automatically provided from the station board. Vital auxiliaries such as the circulators are therefore kept running.

(*c*) When a generator is shut down under pre-arranged conditions, the unit-transformer circuit-braker is opened after first paralleling the station transformer.

(*d*) The paralleling of transformers at 6·6kV is effected by using a check synchronising system. There is no interlocking to prevent the paralleling of more than one unit transformer with one station transformer, although this would bring the fault level above that of the switchgear rating. Reliance is placed on operator discipline and care rather than interlocking, because a system of mechanical interlocks was found to be impracticably complicated. The paralleling of transformers at the 415V level is prevented by mechanical interlocking.

(*e*) In the event of a 132kV busbar fault the busbar-section switch opens, together with all the other switches connected to the faulty section. The output of one reactor to the 132kV system is lost, but the associated auxiliaries, with the exception of one gas circulator, still remain connected to the generator terminals. There is also a loss of one circulator on the other reactor fed from the affected station transformer.

(*f*) A fault on any section of the 6·6kV busbars causes the loss of one circulator. The resulting temperature transients in the reactor are not serious and the reactor is not tripped. The remaining seven circulators speed up automatically, and full reactor output can be maintained for two hours in this way if desired.

(*g*) A fault on the unit-transformer infeed section of a unit board is cleared by the opening of the unit-transformer switch. The busbar-section is intertripped and a quick-switch transfer is initiated. The healthy section carries only a gas circulator, which is interrupted only momentarily. If the fault occurs on the station-transformer infeed section, the fault is simply cleared by the opening of the busbar-section switch.

(*h*) In the event of the loss of all three turbo-alternators and the simultaneous automatic transfer of three unit boards to the station board, the station transformer is capable of supplying all the auxiliaries of the affected reactor until power is reduced under controlled conditions. There is no need to trip the reactor.

(*i*) If one station transformer is out of

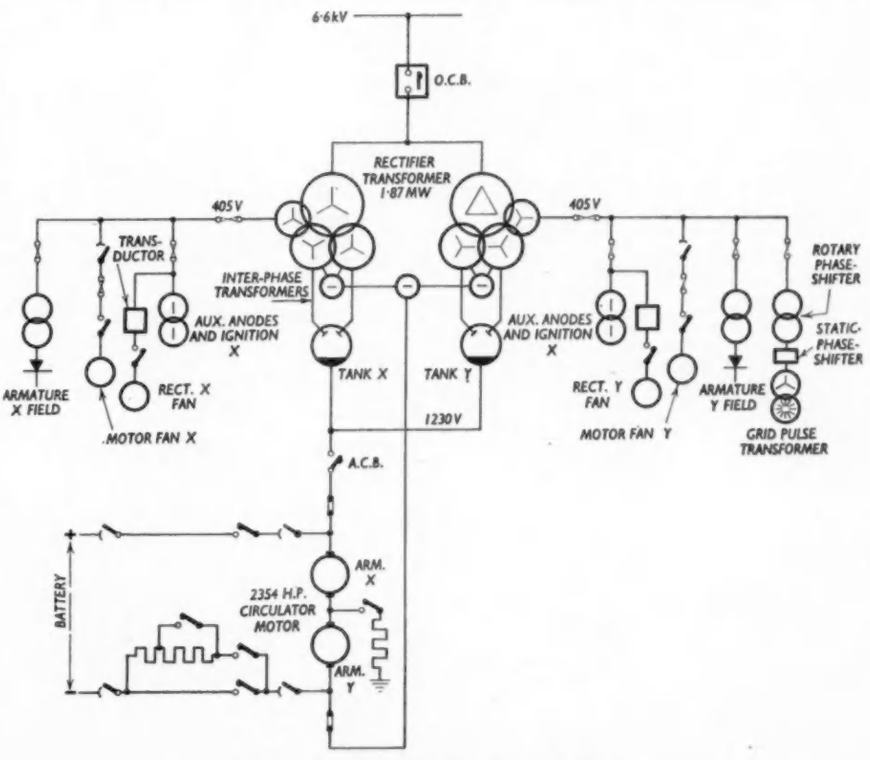


Fig. 6—Circulator-motor main supply system

service, the other can be used to take over the common unit loads imposed on both station boards and also for starting up both halves of the station in succession.

[The authors then described the system of supplies to essential auxiliaries.]

Gas Circulator

Each of the gas circulators is driven by a tandem-armature d.c. motor, which is supplied from mercuty-arc rectifiers with grid control as shown in Fig. 6.

A d.c. motor drive was chosen for a number of reasons which were valid at the time when the basic design of the station was settled. Later developments have allowed gas ducting to be made larger, and in a new design the number of circuits could be reduced from eight to four. The circulator power requirement per gas circuit would then be increased beyond the capability of a d.c. drive and would enter the range where other forms of power, such as direct steam-turbine drive, become more economic. For a variable-speed drive of the power required at Hunterston and the normal speed (1000 r.p.m.) dictated by the contrifugal type of blower, a d.c. drive has many advantages.

The range of speed control of the d.c. motor is exceptionally wide, a very desirable feature. If it is necessary to run the reactor at reduced load the efficiency of the d.c. drive remains high. On the other hand, the machines may be over-speeded for a time without serious loss of efficiency. By over-speeding the blowers, full output can be obtained from a reactor for a short time even when one of the eight steam-raising units or circulators is out of commission. Minor maintenance operations can be carried out on one of the eight circuits without any loss of output for two hours, or with a drop to 95 per cent for an indefinite period.

The d.c. drive also has the advantage that the individual flow rates in each gas circuit may be controlled by a simple adjustment. This is not so easy to do with a.c. drives.

An essential requirement for normal shutting down or emergency conditions is the ability to run the circulators at low speed. With the d.c. arrangement provided, although the normal voltage is 1230V, the circulator motors can be switched directly to the 240V battery system, which can supply them at about one-tenth of their normal speed for some time until the diesel-generators take over [as described in the paper]. Other types of drive require pony motors, which must be mechanically clutched to the main drive; if the pony motor fails to disconnect when the main drive takes over, it will be over-speeded and possibly destroyed.

The natural speed of the circulator motors when driven at 240V is appreciably higher than is required for normal shut down cooling. This is not in itself objectionable, but would result in an unnecessary load on the d.c. system. A small step of resistance is left permanently in series with the armature when the motor is operating at pony speed so that the speed can be adjusted to the correct value. This has an additional value since the resistances of the armatures of these large machines is so low that, in the event of a fault almost anywhere on the d.c. system, the back-feed from the armature into the fault would blow the supply fuses. The small resistance step prevents this.

The circulator impellers actually run within the base of each steam-raising unit, and in the original conception, the motors were to have hung from the underside of each unit. It was later decided, on the advice of the United Kingdom Atomic Energy Authority, to increase the safety of the system by two modifications : one, to raise the heat exchangers relative to the reactor in order to increase the natural circulation of the coolant gas by convection, and the other, to add mechanical inertia to the circulator drives so that they would decelerate more slowly after an interruption of supply and prevent a transient overheating of the reactor. The present arrangement, therefore, includes a considerable length of vertical shafting between each motor and impeller with a heavy flywheel mounted in the middle of the drive. This modification has not affected the electrical characteristics of the drive in any way.

Driving Motors.—The continuous maximum rating of each of the circulator motors is 2354 h.p. This requires a power input of 1750kW per motor, and the emergency 25 per cent overload rating for two hours is 2945 h.p. Two 2¼ h.p. fans blow filtered cooling air on to the motors through ducting.

The most common criticisms levelled against d.c. machines by electrical engineers concern the commutator and brushes. Difficulties from this source have been experienced on the Calder Hall reactors, but there is no reason to believe that these particular troubles will occur at Hunterston. The designers expect an average brush life of three months at full load on the Hunterston machines, and the manufacturers have developed a special tool for changing brushes on load. This tool has been tested both in the works and at site and has been found to be satisfactory, each brush change taking about 10 minutes.

Rectifier System.—As will be seen from Fig. 6, each of the eight rectifier transformers contains two primary, four secondary, two tertiary and three inter-phase windings in a single tank. The twelve-phase supply is rectified to 1230V d.c., while the two 405V tertiaries supply some of the circulator auxiliaries, motor excitation, rectifier ignition, excitation and control circuits.

The action of the three inter-phase transformers ensures that all four secondary windings of the main transformer operate in parallel, i.e. the two bulbs operate as four three-phase rectifiers, two rotating arcs being contained in each bulb. The output from both rectifiers is switched by a single-pole single-break high-speed d.c. air circuit-breaker connected to the circulator motor. The motor field supply is obtained from the transformer tertiaries via stepdown transformers and semiconductor rectifiers. Permanently connected in parallel with this supply is the station 240V battery, the two systems being interconnected by means of blocking rectifiers to ensure that the battery is not charged from the field-rectifier supply.

The standby supply from the station 240V battery is connected to the load side of the d.c. circuit-breaker through contactors. The centre point in the series connection between the two armatures is the earth point of the circulator motor system when the supply is derived from the mercury-arc rectifiers. The system is resistance-earthed, and a contactor is used to disconnect the earth when the motor is running on the standby supply. This is because the 240V battery system is separately earthed.

Speed Control.—The twelve grids of the mercury-arc rectifiers are energised from a twelve-phase grid-pulse transformer supplied from one of the main transformer tertiary windings, via a rotary phase-shifter and a static phase-shifter in cascade. The grid-pulse transformer provides a square-wave[4] grid bias, whose phase can be adjusted by either the rotary or the static phase-shifter. The rotary phase-shifter is an induction regulator driven by a small motor. As the output voltage of the rectifier is proportional to the cosine of the angle of phase-shifter, a cosine compensating mechanism is incorporated in the induction regulator drive which changes the relationship between the movement of the phase-shifter drive shaft and the rectifier output voltage into a linear one.

The static phase-shifter is a three-phase transductor which is required only for automatically limiting the current taken by the gas-circulator motor under abnormal conditions. Control of the motor under normal conditions is by means of the induction regulator. The effect of the transductor is to override any current increase called for by the induction regulator. This is necessary to provide smooth acceleration of the circulator motor following a short period of interruption of supply from the rectifier. This could occur either because of a backfire (followed by auto-reclosure of the circuit-breaker) or because of a severe voltage depression on the 6·6kV supply caused by a " quick-switch " or a 132kV system fault.

The transductor itself is controlled by a current-limiting amplifier. A signal, indicating an excessive current flow, is derived from the primary (a.c.) infeed to the main rectifier transformer, by means of a current transformer and rectifier. This signal is amplified and then fed to the control coil of the tranductor.

When the circulators are required to over-speed, the necessary field weakening is provided by field rheostats driven by a.c. servo-motors.

In the event of a total a.c.-supply failure, a diametrically opposite pair of circulators, which are preselected from the central control room, are automatically connected to the 240V battery supply. Suitable interlocks are provided to ensure that the speed and voltage of the motor are correct before the standby supply contactors are closed. Any other circulators apart from the preselected pair can be switched to the standby supply locally.

Practical Testing.—In view of the unusual nature of the gas-circulator drive and its special importance, it was decided to test a prototype on site at an early stage. The programme did not permit these tests to be carried out with an impeller running in a pressurised gas circuit, so a second circulator motor was mounted at the impeller end of the drive shaft, and the whole was run as a Hopkinson back-to-back test with the rectifiers supplying the system losses only. The primary reason for the tests was to prove mechanical reliability and this was shown to be entirely satisfactory. At the same time the opportunity was taken to check the stability of the rectifiers and associated electrical equipment. The tests occupied nine months.

Reactor Start-up

Operating Staff.—The station superintendent and his deputy are responsible for the operation and maintenance of the station. The shift staff will include a charge engineer with two assistants. One of the latter will be responsible for the operation of the station control room from which both reactors, the turbo-generators and associated switchgear are controlled. In the control room there will also be three junior technical staff, two of whom will be stationed at the reactor control desks and one at the electrical control desk. The technical staff for both operation and maintenance will number about sixty in all. There will be 180 plant operators and 125 maintenance men including fitters, electricians, instrument mechanics, mates and so on. It is

expected that the remainder, consisting of clerical staff, laboratory assistants, &c., will bring the total up to between 400 and 450.

Reactor Start-Up.—The following is a brief outline of steps involved.

(*a*) It is assumed that a reactor is being restarted after a prolonged shutdown. Two circulators are running at minimum speed, the remaining six circulators being shut down and isolated. All control rods are down with the exception of a group of safety rods, which remain continuously withdrawn except when released as the result of an emergency reactor trip. A little steam is being generated in the two steam-raising units through which gas is being circulated, and is being discharged to the dump condenser.

(*b*) The six shut-down gas circuits are recommissioned one by one. The valves are opened and a plant attendant checks that each circulator in turn is mechanically ready for commissioning by checking the lubrication, cooling, &c. As each machine is prepared, the attendant notifies the control room by telephone.

(*c*) To start a circulator, the control-room operator turns the control switch to the "start auxiliaries" position. This closes the circuit-breaker on the a.c. side, and the rectifier auxiliary anodes begin to fire. At the same time various transformers and the rectifier and motor auxiliaries are started automatically. In the control room, the control-switch discrepancy lamp flashes at first and then steadies when all the auxiliaries have been started. The control switch in its next position closes the d.c. circuit-breaker; the main anodes of the rectifier begin firing and the circulator motor starts. The rotary phase-shifter will have run automatically to the minimum-speed position when the circulator was shut down, so the motor will be running at low speed.

(*d*) When all circuits are commissioned, the operator brings the reactor to criticality by running out the control rods. When a small amount of positive reactivity has been added, the control rods are stopped and the fission power increases at a controlled rate until an appreciable amount of heat is being generated. Various adjustments have to be made to the nucleonic instrumentation at this stage.

(*e*) For the next stage, the rate of rise of fuel-element temperature becomes predominant. Limitations concerned with the differential expansion of various parts of the structure are rigorously observed. When the fuel-element temperature has reached a value approaching the design value, some megawatts of heat will be generated even at the minimum circulator speed of 10 per cent. The steam pressure is allowed to build up until the quality of the steam being passed to the dump condenser is sufficiently high to be passed to a turbine for warming through, running and synchronising.

(*f*) With the first turbine commissioned, power may now be raised by increasing the circulator speed. The control-room operator turns the circulator control switches to the "group" position, and control is now available to the operator from his desk to raise speed with all circulators ganged together. As power is raised, the fuel-element temperature will be brought up simultaneously to the design value. The remaining turbines are commissioned as soon as sufficient steam is available.

With the reactor on steady load, the overall station control equipment described above is brought into commission and the start-up operation is then complete.

[The paper then gave a brief description of normal operation.]

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High-Speed Tinplate Line

Most of the world's tinplate is now produced on continuous electrolytic tinning lines. Richard Thomas and Baldwins Ltd. installed the first electrolytic line outside the U.S.A. at Ebbw Vale, in 1947, *and this line is still at work. A second line has now been put into production at Ebbw Vale. The new line, though operating on the same basic principles, is much larger than the original one (it is claimed to be the largest in the world), and has a number of novel features in its design.*

TINPLATE was originally produced by dipping cleaned steel sheets in molten tin, and a certain amount is still made in this way when heavy tin coatings are required. Most of the tinplate used to-day, however, has lighter tin coatings than can be produced by hot dipping, and the electrolytic process, which is also capable of much greater outputs, is the principal means of production. The original electrolytic line at Ebbw Vale is capable of applying coatings of ½ lb of tin per basis box (a box represents 217 square feet), at 600ft per minute, and has an output of 2,500,000 basis boxes per annum. The new line will apply tin coatings up to 1 lb per basis box, thus filling the gap between the ½ lb coatings of the No. 1 line and the 1 lb and over coatings of the hot-dip process. It can also provide coatings down to ¼ lb per box, and can coat plate from 0·168mm to 0·56mm thick, the maximum sheet sizes being 37½in by 37in. The operating speed is 1500ft per minute, and the line can supply tinplate within the size range stated either as cut sheets or in coils.

There are four main components of the complete installation: a coil preparation line, a "Ferrostan" electrolytic tinning line, a pair of tinplate cut-up lines, and an inspection and sorting line. With the exception of the civil engineering work and the supply of power and other services, the installation was engineered by The Head Wrightson Machine Company Ltd., Middlesbrough, in co-operation with the Ebbw Vale engineering departments, and designed by Head Wrightson in association with the Aetna Standard Division of the Blaw Knox Company, Pittsburgh, Pa., U.S.A. It is housed in a new building 770ft long, 90ft wide and 48ft high to the eaves, erected on land levelled and filled for the purpose near to the existing cold mill buildings.

Cold rolled steel strip for the tinplate line is received in coil form from the cold rolling mills and prepared in the coil line, which incorporates improved designs of pay-off and tension reels, a seam welder and an edge trimmer, and operates at a top speed of 4000ft per minute. It has a rated output of 300 tons a shift, the strip being edge trimmed and built up into 36,000 lb coils ready for tinning. Continuous gauging is incorporated, and provision is made for cutting out off-gauge material and re-coiling it on a reject tension reel. The two 300 h.p. coiler motors and the 45 h.p. trimmer motor are on a single Ward-Leonard bus, but each motor has its own booster so that it can be individually controlled. Stopping is normally by re-generation through the m.g. set, but in emergencies, dynamic braking is applied, assisted by very powerful disc brakes on the coiler and pay-off reels. Finished coils are transferred from the coilers to a horizontal conveyor for temporary storage and weighing on a scale incorporated in the conveyor.

Prepared coils are fed into the "Ferrostan" line from one of two pay-off reels and pass through a shear, where the leading edge of the strip is trimmed ready for welding to the tail end of the strip which is already in the line, and which has previously been trimmed at the welder shear. The two strip ends are welded, and the strip passes through an entry pulling bridle which, together with the pay-off reel, is accelerated to top speed to fill the three looping pits which are next in the line. Passing up from the pulling bridle, the strip runs through four pairs of pinch rolls at the top of a tower and hangs down into the pits to form three loops 90ft deep, thus providing a reservoir of strip some 500ft long which allows for changing coils on the pay-off without interrupting the process work which follows. Four infra-red photocells in each pit control the length of the loops.

After leaving the looping pits the strip passes through a cleaning and pickling section and a brush scrubber before entering the plating section proper.

PLATING

Although the "Ferrostan" process of the United States Steel Corporation has undergone little fundamental change since the first Ebbw Vale line was installed, the high speed of the present line brought design problems not hitherto encountered on "Ferrostan" lines. Stoppages for maintenance and for other purposes must be kept to a minimum, and this entailed designing the equipment to facilitate quick changing of the rolls. To keep the plating current density within the range of 150A to 300A per square foot, special controls for the sequential switching of the plating rectifiers have been incorporated.

One of the main problems envisaged at speeds around 1500ft per minute was that of containing the electrolytes in the processing tanks. To study this problem The Head Wrightson Machine Company built at Middlesbrough a full-scale working model of a process tank, using water and "Stergene" to simulate the viscosity and surface tension characteristics of the plating electrolyte. These investigations led to the design of special splash guards for conductor and scrubber rolls, and shields for the up-pass anodes and anode bridges. The old design of individual plating tanks, each having one down pass and one up pass and a central overflow weir across the tank, has been discarded in favour of an upper tank equivalent to four of the single cell units. This presents a greater surface area to reduce the turbulence. The overflow weir is now combined with a spillway which runs round both sides and both ends of the tank, the outer plates of the spillway being raised above the level of the weir.

Three of these large plating tanks are provided, making a total of twenty-four

Ebbw Vale electrolytic tinning line from the exit end. One of the cut-up lines is on the left

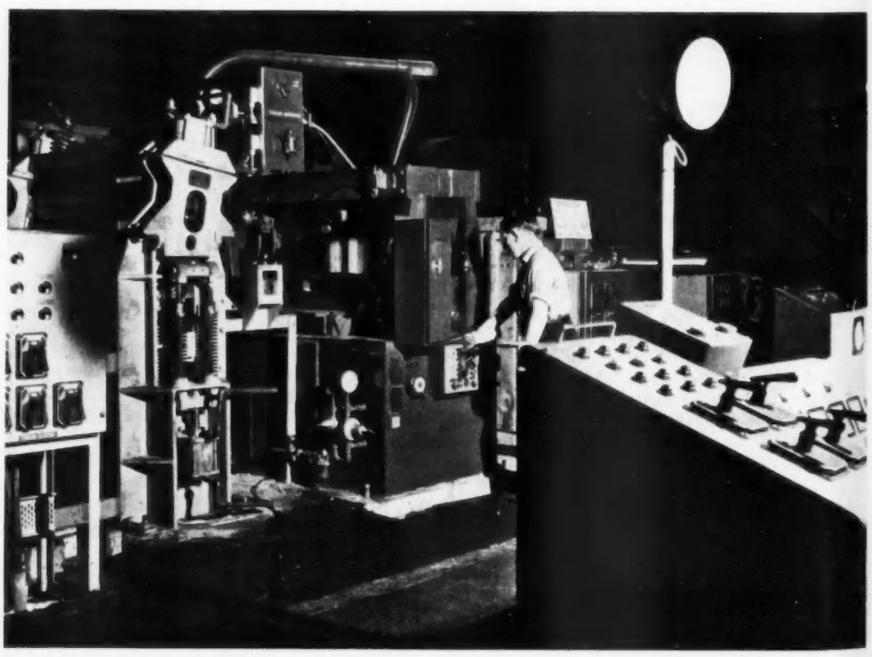
plating passes. All the passes are switched on for plating only when the line is producing the heavier coatings at high speed. For lighter coatings and slower speeds, sixteen, twelve or even eight passes only are required. Replenishment of tin anodes on the forty-eight bridges is a continuous operation, so to assist in pushing the banks of anodes across the bridges, a small hydraulic jack is fitted to each bridge.

Easy accessibility to all points in the line is essential if the time spent on maintenance is to be kept to a minimum. Earlier " Ferrostan " lines have been criticised on the grounds that the processing tanks were suspended through the mill floor, and the sink rolls were only accessible from the basement. The new line, on the contrary, is elevated, all the tanks being above floor level, and an operating platform is provided 10ft 9in above the floor. This platform, which also carries the main control panel, is over 30ft wide, and runs the whole length of the processing section of the line.

Correct tracking of the strip is of major importance. All the rolls must be correctly aligned, but to ensure good tracking the strip must be under tension. The drag bridle at the entry end and the drive bridle at the exit provide the tension and the motive power to pull the strip through the line. Between these bridles the strip takes a serpentine path over or under eighty rolls, each one of which is individually driven by a 5 h.p. geared motor to overcome the inertia, thus ensuring that the bridles will provide invariable tension at all times. Those rolls which operate in liquid have an over-riding speed control, so that when a liquid film forms between the strip and the roll at high speed, the rolls remain at strip speed, although the load is removed. This prevents skidding and marking of the strip surface when the line decelerates again. Surface finish is, of course, of prime importance.

The conductor roll assemblies are mounted in pedestal bearings which rest on deep beams, the pedestals and seatings being drilled and machined to jigs to enable complete assemblies to be changed quickly. These assemblies comprise the 24in diameter conductor roll and pedestals, drive motor and gearbox, snubber roll and beam, snubber roll air piping, and splash guards. There are no heavy beams, from which the conductor rolls were underslung on earlier lines; thus clear access by the shop crane to the centre of the line is possible. The anode hoists and runway beams are suspended from a tubular girder which is mounted on end carriages high above the plating bath. To give access to the conductor rolls by the shop crane, the girder carrying the anode hoists can be traversed sideways on its gantry.

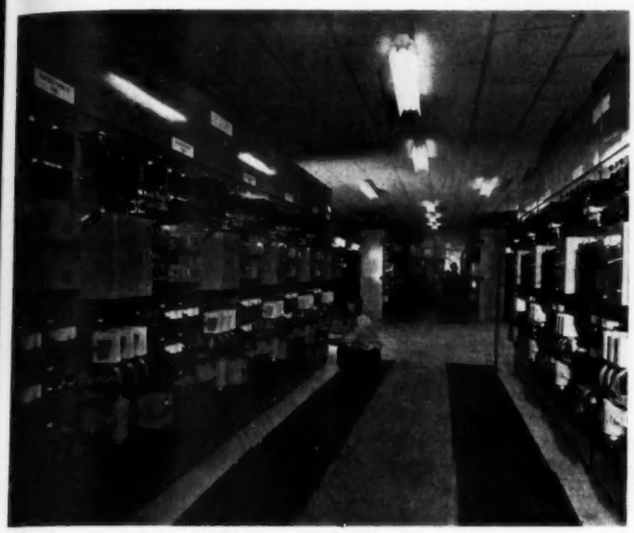
Tinned strip leaves the plating process with a matt surface, which is not generally acceptable to tinplate users, and the line, therefore, incorporates flow melting equipment to melt the coating and quench it immediately, so improving both the appearance and the quality. This melting is done by passing an alternating current of several thousand amps through the strip as it passes between two conductor rolls. Control of the melting, or flow brightening, is automatic, from photoelectric cells which measure the brightness of the molten tin on the strip. The melted coating section in previous lines was always a congested area, particularly at floor level, where the conductor rolls and quench tank



Coils for tinning are prepared by trimming on the line shown above, where off-gauge strip is also cut

are located, so in the present line individual parts have been made more accessible by the provision of two water-cooled deflector rolls at the top of the muffle furnace, so increasing the centres of the up and down passes to 8ft. The No. 2 conductor roll is no longer placed in the quench tank ; instead, it is mounted above the wringer rolls on the exit side of the tank.

A feature of the present line is the provision of a strip printer on the entry side of the flow-melt unit. This can be used, when differential tin thicknesses are being produced, to print thin lines of fluid on the strip surface. These become visible after melting, and enable the tinplate user to identify the side carrying the lighter coating. A high-voltage electrostatic oiler is also incorporated in the line for the application of heavier films of oil. It can be used as an alternative to the normal emulsion oiler also in the line, or supplementary to it.



Control panel for electrolytic tinning equipment

Plated and flow-brightened strip emerges from the line to a coiler, passing on the way an inspection point, where two 15ft vertical mirrors are so arranged as to allow an inspector to see both sides of the strip. For more detailed examination of the surface a pair of scanning units is also provided. These consist of a rotating drum, synchronised with the strip speed, and carrying twenty small flat mirrors on the surface ; these mirrors reflect, momentarily, a stationary image of a piece of the moving strip.

Cutting and Sorting

Tinplate can be despatched in coil form as it leaves the coiler at the end of the line, but at present the greatest demand is for plates cut to size from the coil. As it is possible to produce the tinplate much faster than it can be sheared, two almost identical cut-up lines are provided. No. 1 line is placed in tandem with the tinning line and can be used as an extension of it if required. When this arrangement is in operation, the tinning line would be running at a lower speed.

Each cut-up line incorporates equipment for the automatic classification of the cut sheets, which are sorted into four piles according to whether they are prime, off-gauge, pin-holed or marred by surface defects. The monitoring instruments must operate on the continuous strip, and visual inspection is also carried out before shearing. All the fault signals are synchronised with the moving material using digital logic techniques, and after shearing, the signals are related to individual sheets ; thus only the faulty ones are rejected. As the visual inspection is actually carried out at the end of the tinning line, means must be provided for relating the fault signals to the strip when it is uncoiled for shearing. This is done by means of a paper tape in which holes are punched automatically for rejected increments of strip. To avoid error these increments are related to half turns of the coil. The tape is terminated with the operation of the snip shear at the end of the tinning line, and is transferred with its associated coil to the cut-up line. It is then put through a tape reader in the reverse direction, and the signals are fed into the classifier logics. Diversion of the cut sheets in the classifier, according to the signals received, is by electromagnetic rolls, which can pick out and divert a single sheet at speeds up to 1000ft per minute.

When tinplate is sold in coil form it is desirable that a record be available of the amount of prime and reject material in each coil. This record is produced in tabulated form by the production analyser, using techniques similar to those of the single sheet classifier. The information provided is : total length of coil, prime length, pinhole length, over-gauge length, under-gauge length. These are given in feet, and printed with additional information, such as order number, width of strip, and substance.

Electrical Equipment

The electrical equipment for the line was sub-contracted by Head Wrightson to four main suppliers. The General Electric Company, Ltd., supplied all the d.c. and a.c. drives on the electrolytic tinning line, comprising 108 d.c. motors of powers ranging from 5 h.p. to 170 h.p., and fifty-five a.c. machines from 1 h.p. to 75 h.p. The d.c. drives, which are used for line speed control, are fed from eight d.c. generators, on two main motor generator sets, and the a.c. drives, which are used mainly for pumps and fans on the line, are fed from the low-tension distribution system. Control of the generators and other d.c. equipment is by means of 400-cycle magnetic amplifiers, in order to give accurate control of strip speed and tension. The main motor generator sets are driven by a.c. squirrel-cage motors, fed from the 2·2kV supply.

Low-voltage rectifier equipment to provide the 215,000A of d.c. for preparation and tin plating of the strip was supplied by the Westinghouse Brake and Signal Company Ltd., London, N.1. This equipment incorporates transductor-controlled germanium rectifiers as follows : four units, each of 5000A at 30V, for the cleaning section ; two units, each of 7500A at 22V, for pickling ; twenty-four units, each of 7500A at 18V, for tin plating ; and one unit of 7500A at 18V for chemical treatment. Control of the current from the plating rectifiers is arranged to be proportional to line speed to within ±1 per cent.

British Insulated Callender's Construction Company Ltd., London, supplied and erected the complete busbar system for transfer of the heavy current from the low-voltage rectifiers to tanks on the tinning line. About 24 tons of solid-drawn copper bars were used on this installation.

Reflow equipment for the electrolytic tinning line, comprising saturable reactor control of two 1500kVA high-tension transformers feeding current to the strip for heating was supplied by the English Electric Company Ltd., Stafford. This company also supplied the line drives and control equipment for the two cut-up lines, the coil preparation line and the inspection line, comprising forty-three d.c. motors and forty-four a.c. machines. English Electric supplied, in addition, the electronic equipment for controlling the sheet classifiers, and the production analyser. F. H. Wheeler and Co. Ltd., Cardiff, was responsible for supplying and installing the complete cable work.

Books of Reference

University College Calendar, 1961–62. University College, Gower Street, London, W.C.1. Price 16s. (8s. to students of the college.) —This volume gives dates of terms and college meetings, a short history of the college, names of members of the committees, tutors, departments and staff, technicians, wardens and other information concerning the college and its staff. The prospectuses for the various faculties and departments are included along with information on scholarships, exhibitions, awards for undergraduate study, prizes and medals, and bursaries. Other information includes the college library, museums and collections, regulations and statutes governing admission of students, examinations, and management. There are also lists of Fellows and Honorary Fellows, former professors, officers of the college, and publications, and an index.

[Reply Card No. 1211]

Basic Road Statistics, 1961. British Road Federation Ltd., 26, Manchester Square, London, W.1. Price 1s.—For every 38 yards of road in Britain there is one vehicle : there are 33·2 vehicles of four or more wheels per mile of road —6·2 more than West Germany and 12·2 more than the United States. The British figure is 46·5 when motor-cycles and other vehicles are added. These are figures given in the latest edition of *Basic Road Statistics*, 1961 which is now well known as a standard guide on road matters.

The total number of vehicles in use in 1960 was 9,383,140, 5,000,000 more than in 1950. Five-and-a-half million of that figure were cars, more than in any other country except America. In 1960–61 road users paid £661,300,000 (11·1 per cent of the national revenue) in motor taxation—over five times more than ten years ago, when the percentage of national revenue was 5·3. The Government's share of spending on the roads in 1959–60 amounted to £98,851,000 —less than one-sixth of taxation. In addition, local authorities spent about £89,000,000. The total cost of road accidents to the community was £229 million—£10,000,000 more than in 1959.

[Reply Card No. 1274]

Letters to the Editor

ON THE MEANING OF UNIFIED EQUATIONS RELATED TO WEIRS FOR MEASUREMENTS OF OPEN CHANNEL FLOW

SIR,—May a few comments be permitted on the article by Dr. Engel and Mr. Stainsby in your issue of September 29 in an attempt to bring this interesting work into perspective?

The expression for the free-discharge per unit throat width through a "long structure" under idealised circumstances, namely,

$$q_{ideal}=(2/3)^{1\cdot5}C_{va}(g)^{0\cdot5}h^{1\cdot5} \quad . \quad . \quad (1)$$

is rationally derived. The discharge coefficient C, by which the expression is multiplied to obtain the real flow-rate, must then take account of all the various deviations from the assumed ideal conditions.

Turning to free-discharge over a two-dimensional sharp-crested weir, the usual discharge expression :

$$q=(2/3)C_d(2g)^{0\cdot5}h^{1\cdot5}$$

is irrationally based. Why not, therefore, disregard this form and write directly from equation (1) :

$$q_{ideal}=K(2/3)^{1\cdot5}C_{va}(g)^{0\cdot5}h^{1\cdot5}$$

where the constant K takes account of the switch from rectilinear to curvilinear free-discharge conditions? However, the fact that the value of K turns out to be closely $(3)^{0\cdot5}C_c$, where C_c is the contraction coefficient for gravity-free flow of ideal liquid through a two-dimensional slot, must be regarded as fortuitous in the absence of an acceptable theoretical treatment of the curvilinear discharge of the nappe. The authors' attempt at justification wherein rectilinear flow relationships are applied to the curvilinear discharge is felt to be unsatisfactory.

Nevertheless, the authors' effort to separate the velocity-of-approach and contraction influences from the discharge coefficient deserves support as an attempt to break clear of the jungle of past practice. But is this step sufficient? The writer thinks not for the reason that after separation of these two influences from the discharge coefficient too many influencing factors still remain. Thus, not much confidence is felt in the authors' suggestion that the remaining influences might be sorted out by exploratory plotting of the coefficient against supposedly relevant dimensionless groups.

The long-term aim of such work may be said to be an elucidation of the flow mechanism enabling economical metering structures to be designed which will consistently provide predictable coefficient values constant over as wide a discharge range as possible. It is submitted that significant progress in this direction will be achieved only when analysis also permits of the exact expression of the discharge coefficient C value in terms of the relevant factors. The authors in contrast appear resigned to empirical C values.

Thus, the writer has recently derived rational analytical expressions for the discharge coefficient of simple forms of broad-crested weir (paper submitted for publication elsewhere). It is hoped to extend the analysis to embrace other types of long structure. Not only does such analysis automatically reveal the significant dimensionless groups and how each influence affects the coefficient value, but the way is pointed to means of improving the measuring efficiency of the devices.

Summarising, the most direct route towards effecting improvement of metering devices is through complete understanding of the flow mechanism (of which velocity-of approach and contraction effects play only a part). Work directed towards that end should accordingly be vigorously supported.

G. W. HALL

Royal Military College of Science,
Shrivenham,
November 23, 1961.

NOTABLE LOCOMOTIVES OF 1911

SIR,—Your correspondent, Mr. Goffey, in your issue of November 24, 1961, does me an injustice when ascribing the remarks I made concerning the Robinson 2–8–0 type engines as being "unfortunate"; nothing derogatory was said or inferred concerning these locomotives which, as your correspondent says are "generally considered to have been very satisfactory." That such is the case is fully borne out by the fact that, I believe, no less than 571 of these locomotives were supplied to the orders of the War Office for service overseas during the 1914–18 war.

Concerning Mr. Goffey's statement that "it is hardly correct to suggest that the Great Western 43XX class 2–6–0's were the first mixed traffic locomotives in the country," I can only say that I suggested nothing of the sort ; I simply stated that these locomotives were introduced for mixed traffic on the Great Western Railway, and then went on to say that they proved to be the forerunners of others of the same type on other railways, mentioning the Great Northern and the South Eastern and Chatham railway. I submit that it is quite impossible to infer from these remarks that I was under the impression that these were the first locomotive used in this country for this class of traffic.

I willingly concede that I overlooked the tenders used for Wilson Worsdell's "R" class engines and offer my apologies for so doing. I also regret having misquoted the weight available for adhesion in the case of the Brighton "Atlantics."

E. C. POULTNEY

Eastbourne,
December 5, 1961.

FACILITIES

SIR,—I am astonished that you should attempt to defend the popular misuse of the word "facility" in a leading article in your issue of December 1. Facility is an abstract concept, and to impart a concrete meaning to the word is wholly wrong. It is misused mainly in two ways—lazily, as a cliché, when the speaker or writer cannot be bothered to think of and apply the right word, and redundantly (and not seldom rather pompously), when it could simply be left out. To take your own examples, hitherto one was invited to inspect the "plant"—an acceptable Americanism. "Sheet shearing facilities" may mean the machine itself, the sheet shearing equipment (which would include drive and control gear), or the sheet shearing plant, meaning the whole installation with building and foundations. Then why not use a correct word which defines what is meant ?

ALEX. C. HIRST

Rugby,
December 1, 1961.

[May we repeat the last two sentences of our article ? "But over here, deplorably, we find the same word only too often misapplied. Misapplication is not unknown in America either." Dictionary definitions (S.O.E.D.) may be helpful. Plant : "The fixtures, implements, machinery and apparatus used in carrying on any industrial process." Facility : "Opportunity for the easy or easier performance of anything; usually in plural."—Ed. THE E.]

STAINES BY-PASS

SIR,—We have read your excellent report in your issue of November 24 on the opening of the above which, however, did not make the point that the Runnymede Bridge has been completed after all in twenty-four months, whereas our lowest tender for this bridge was rejected because it was said that the second lowest tenderer would complete in twenty-one months, although in fact the bridge was not required in less than twenty-four months with the whole By-Pass.

J. E. DAYTON,

Joint Managing Director,
Alderton Construction Company Ltd.,
Westminster,
December 6, 1961.

Books just published

An Engineering Theory of Plasticity

275 pages. Illustrations. Diagrams.
Publisher : Butterworth and Co. (Publishers) Ltd.
by E. P. UNKSOV. Translated by the Production Engineering Research Association of Great Britain.
Price 70*s.*

This is a translation of the book *Ingeneraya Teoriya Plastichnosti* published by Mashgiz, Moscow, 1959. In it the author attempts to develop, and illustrate by experiment, the principles of engineering methods for calculating deformation forces encountered in the principal processes of working metal by pressure. It is not an exhaustive work, for example cold stamping is not included ; but there are chapters on the physical principles of plastic flow, the factors affecting it, the structure of the deformed metal and its mechanical properties. Further chapters cover the study of stress, the experimental basis of the suggested method and its applications. There is a long list of mainly Russian references, and an author and subject index.

[Reply Card No. 1398]

Short-range Guided Weapons

79 pages. Diagrams.
Publisher : Temple Press Ltd.
by J. CLEMOW, M.A., A.M.I.E.E.
Price 15*s.*

This monograph, which serves as an introduction to the Temple Press series of monographs on rockets and missiles, surveys the principles underlying the design of tactical guided weapons. There are chapters on the advantages (*sic*) of

guided weapons, the main parts of a guided missile, aerodynamic and propulsion considerations, methods of guidance, the control system and a hypothetical design problem. There is a brief select bibliography and an index.
[Reply Card No. 1402]

Boundary and Eigenvalue Problems in Mathematical Physics

381 *pages. Illustration. Diagrams.*
Publisher : John Wiley and Sons Inc.
by HANS SAGAN, Ph.D.
Price 76*s.*

In this book the theory of orthogonal functions, Fourier series and Eigenvalues are developed from boundary problems. These topics are linked by Hamilton's principle together with the theory of the first variation and Bernoulli's separation method for the solution of linear homogeneous partial differential equations. The chapter headings include Hamilton's principle and the theory of the first variation, representation of some physical phenomena by partial differential equations, theorems related to partial differential equations, Fourier series, self-adjoint boundary value problems, Legendre polynomials and Bessel functions, characterization of Eigenvalues by a variation principle, spherical harmonics and the nonhomogeneous boundary value problem. Each chapter is followed by problems and a list of recommended further reading. There are appendices on vector analysis, convergence, differential equations and answers to problems. There is also an index.
[Reply Card No. 1378]

Automatic Data Processing

76 *pages. Illustrations.*
Publisher; Her Majesty's Stationery Office: for the Department of Scientific and Industrial Research.
by DEREK WRAGGE MORLEY.
Price 6*s.*

Industry and commerce produce an ever-growing mass of data which, in many cases, has already attained such a volume that it can only be used effectively if processed and analysed in a computer. In the first twenty-five pages the author explains in simple terms what a computer does, how it is instructed to do it, its memory resources, and the methods of feeding information in and taking it out. He then outlines the course of development of data processing in the United Kingdom, showing the contributions of various firms, and proceeds to give examples of its application by a wide variety of users in accounting, payroll work, production control, business forecasting, and many other ways. An appendix describes British and other systems of data-processing available in the United Kingdom.
[Reply Card No. 1417]

An Introduction to Fourier Analysis

126 *pages. Diagrams.*
Publisher : Methuen and Co. Ltd.
by R. D. STUART, M.A., Ph.D., A.M.I.E.E.
Price 13*s* 6*d.*

This monograph is intended for students of science and engineering; thus full mathematical rigour has not been attempted. An elementary proof of the fundamental theorems has been given to provide insight into the more theoretical aspects of the subject and to provide a better basis for understanding of later phenomena. There are chapters on Fourier series, analysis of periodic waveforms, Fourier integrals, analysis of transients, applications to circuit analysis and wave motion analysis.
[Reply Card No. 1404]

Management on the Factory Floor

138 *pages.*
Publisher : Sir Isaac Pitman and Sons Ltd.
by JOSEPH GLOAG, B.Com., F.C.I.S., F.A.C.C.A., M.B.I.M.
Price 15*s.*

This book is intended to examine the function and duties of the foreman or supervisor, particularly in the field of engineering, in relation to the areas of management which lie beyond his immediate participation. The first part deals with the environment within which the supervisor works and also includes costing, work-study, and the care of plant and materials. The second part deals with the people with whom a foreman works and discusses wages, welfare, trade unions, &c., in connection with them.
[Reply Card No. 1405]

Foundation Design Simply Explained

115 *pages. Diagrams,*
Publisher : Oxford University Press.
by JOHN FABER, B.Sc., M.I.C.E., M.I.Struct.E., M.Am.Soc.C.E., M.Soc.C.E.(Fr.), M.Inst.W., A.C.G.I., M.Cons.E., and FRANK MEAD, B.Sc., A.M.I.C.E., A.M.I.Struct.E., A.M.I.W.
Price 15*s.*

The object of this book is to apply the science of soil mechanics to the problems which normally arise in designing foundations. It is intended as a practical guide and an elementary knowledge of reinforced concrete design is assumed. There are chapters on first principles, rocks and soils, simple site investigations, theory of soil behaviour, soil mechanics tests, spread and piled foundations, retaining walls, and materials and construction. There is a subject index.
[Reply Card No. 1406]

Principles of Modern Building. Vol. II. Floors and Roofs

189 *pages. Illustrations. Diagrams.*
Publisher : Her Majesty's Stationery Office.
Price 17*s.* 6*d.*

This book appears as the collective work of the staff of the Building Research Station and completes the publication of a work intended to provide a framework of study for the student and a reference book for the practitioner. There is an introductory chapter on basic requirements; then chapters on floors include suspended and solid floors, finishes and heating. Flat, pitched, shell, and other special types of roofs are discussed. Vol. I dealt with principles of design and functional requirements of buildings as a whole; the third edition of this appeared in 1959.
[Reply Card No. 1407]

Copper and Copper Alloy Castings

51 *pages. Illustrations. Tables.*
Publisher : The Association of Bronze and Brass Founders, 69, Harborne Road, Edgbaston, Birmingham 15.
Price 21*s.*

The British Standard for copper alloy ingots and copper and copper alloy castings, B.S. 1400 : 1961, brings up to date the standard which appeared in 1948; this booklet is issued as a companion volume to the standard and is a guide to the alloys, their uses, properties and casting characteristics. It also includes a summary of the specifications, and equivalent specifications, as well as photomicrographs of typical alloy structures. The pamphlet is spirally-bound between stiffened paper covers.
[Reply Card No. 1397]

Kunststoffe : Struktur, physikalisches Verhalten und Prufung. Vol. 2. Praktische Kunststoffprufung

656 *pages. Illustrations. Diagrams.*
Publisher ; Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3.
Edited by RUDOLPH NITSCHE and KARL A. WOLF. Volume 2 *edited by RUDOLPH NITSCHE and PAUL NOWAK.*
*Price DM.*112

The layout and equipment of a testing laboratory for plastics depends, next to the intended scale of operations, upon whether or in what proportions fundamental or technological investigations, are to be carried out. While many details of testing equipment and procedures are given, the main object is not to deal with these exhaustively, but to describe concisely the principal ones among them, concentrating largely upon mechanical-technological methods.
[Reply Card No. 1418]

Rohrleitungen in neuzeitlichen Warmekraftanlagen : Planung, Berechnung und Ausfuhrung

208 *pages. Illustrations. Diagrams. Folding Tables.*
Publisher : Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3.
by OTTO SCHONE and ERICH SCHWENK.
Price DM. 48

A very large proportion of a modern power station consists of pipes for steam, condensate, cooling water, &c. In particular, the working parts of the boilers consist almost entirely of pipework subjected partly to the most severe conditions. Pipe systems for modern power stations are discussed in the present volume both from the point of view of their general layout, with particular attention to stability and economy, and from that of detailed design. Throughout, the aim is to assist the newcomer to this field as well as the practical engineer of many years experience.
[Reply Card No. 1440]

The Science of Daylight

285 *pages. Illustrations. Diagrams.*
Publisher : Macdonald and Co. (Publishers) Ltd.
by JOHN W. T. WALSH, O.B.E., M.A.(Oxon.), D.Sc.(Lond.).
Price 40*s.*

This book attempts to collate the widely scattered literature of this subject and its many applications. The author has collected material from such fields as physics, architecture, building, design, interior decoration, town-planning, and health work. No attempt is made to give each aspect an exhaustive treatment, but each chapter has an extensive bibliography. The work includes an index, tables, notes, and a list of journal abbreviations used in the references.
[Reply Card No. 1460]

Metallurgy in the Service of Man

372 *pages. Diagrams.*
Publisher : Macdonald and Co. (Publishers) Ltd.
by W. H. DENNIS, B.Sc.(Lond.), M.I.M.M.
Price 45*s.*

The author endeavours to present some of the chief aspects in the field of metallurgy, both in general principles and industrial applications. This book should be of interest to students of engineering, practising engineers, and interested laymen. Chapter headings include production of iron, ore to metal, iron to steel, structure of steel and heat treatment, cast iron, mechanical properties, shaping of metals, non-ferrous metals, lightweight metals, minor metals, uranium and the atomic age, precious metals, and rare metals. For most metals, the book gives the following information: occurrence, properties and uses, recovery, alloys, and properties. Each chapter has a short bibliography, and an index completes the volume.
[Reply Card No. 1461]

Sources of Energy and Industrial Revolutions

50 *pages.*
Publisher : European Coal and Steel Community
by PIERO MALVESTITI.
No price given.

This is a translation of an essay by Professor Malvestiti which appeared originally in the review " Economia Internazionale delle Fonti di Energia." It is a political and economic survey, and is stated to be a recapitulation of all studies on this subject to date. The author is President of the High Authority of the European Coal and Steel Community.
[Reply Card No. 1462]

Automatic Feed Line for Cutting Transformer Laminations

A NEW automatic machine for cutting transformer core plates has been installed in the Distribution Transformer Department of Ferranti Ltd., at West Gorton, Manchester. Distribution transformers up to 1500kVA and "conventional" cores are made by flow-line production methods at this factory.

The introduction of this new machine follows a period of intensive work on the development of automatic feed lines for the production of transformer core laminations. Since the advent of cold-rolled grain-oriented steels, which are supplied in the form of coiled strip, Ferranti Ltd. has been seeking a suitable method of feeding and cutting the coils automatically. The main objectives were to increase productivity; to reduce the scrap content involved in the usual methods of manually controlled cutting; and to minimise handling which was causing bottlenecks in the production of laminations.

At first the company had difficulty in finding a manufacturer who could produce a feed line to cut and measure the strip to the necessary tolerances. However, this task was eventually undertaken by B.H.P. Machine Tool Company Ltd., of Birmingham, which produced an automatic line designed to feed the material with constant accuracy to within 0·015in per length; to provide for quick changeovers from one length to another (3⅞in minimum to 41½in maximum); to give the maximum feed rate possible (40ft per minute) consistent with this high degree of accuracy; and to accommodate varying widths of material ranging from 1½in to about 8½in.

This feed line uses a motorised roller feed and is controlled electrically by electromagnetic clutches and brakes. It comprises individual units, such as a B.H.P. decoiling unit and feeding machine; an H.N.E. combined press and cropping tool; a Londex control panel on which the required length of feed can be preset; a Ferranti lamination dispenser unit; and a batch counter. The latter automatically switches off the feed line when the required number of laminations have been produced. This line has been in constant operation since 1958 and has produced core laminations with greater accuracy than was possible with manually controlled guillotines.

Compared with this pilot line, the recently installed feed line, designed and manufactured by Humphris and Sons Ltd., of Poole, Dorset, is completely integrated and is about three times as fast, i.e. 120ft per minute minimum. Prediction of cut length is positive and accurate, and generally the changeover time in setting different lengths is faster. It is used for the production of "conventional" core and mitred core laminations. It comprises a control cabinet; loop control unit, incorporating a photo-electric cell; a decoiler; a loop support unit, fitted with a micro switch to control a no-loop condition; a feeding and measuring machine incorporating pinch rolls, measuring rollers, and entry and exit guides; a Humphris "CP25 Pressmaster" open-front power press, complete with an oscillating mitre cutting tool; and a run-out table and stacking unit for the finished transformer laminations. A characteristic of the oscillating press tool, which is fitted with tungsten carbide shear blades, is that air flotation is used to assist free angular movement through 90 deg. giving alternate 45 deg. mitre cuts.

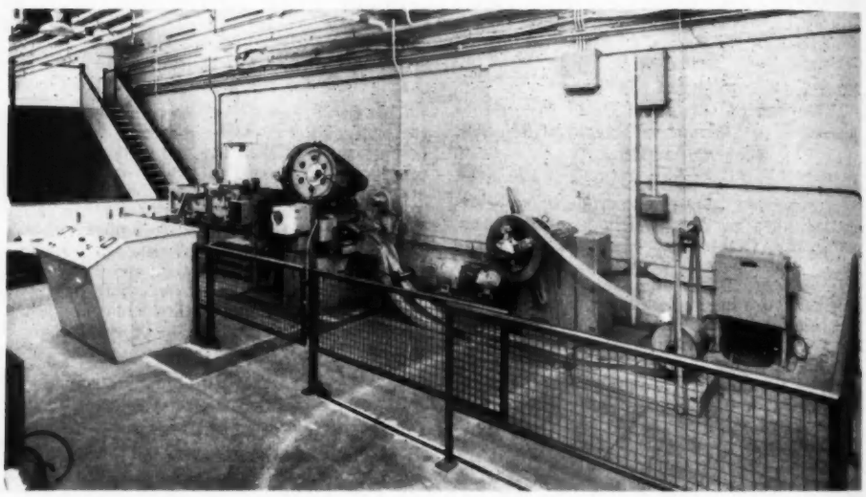
Although the arrangement of units is similar in the two lines, the method of measuring the length of material to be cut differs considerably. In the original line, a perforated 12in diameter "Tufnol" disc with 120 divisions is mounted at one end of the combined feeding and measuring rollers. Each interruption of the light beam on a photo-electric cell caused by the disc rotating corresponds to 0·015in length of strip and actuates a "Dekatron" counter on the Londex control panel. There are four decade selector switches on the panel, each with a dial counting up to 10, and they are set to the number of pulses corresponding to the required strip length.

In designing the new feed line (which gives a greater maximum output and quick, accurate prediction of length, and greater day-to-day accuracy) Humphris and Sons Ltd., uses a different method to measure the length of material to be cut. An accurate position control servo system (patents pending) jointly developed by Humphris and Sons Ltd. and Laurence, Scott and Electromotors Ltd., of Norwich, was adopted in preference to the "Dekatron" counter system.

As there are no slitting machines in operation at West Gorton, the wide coils of steel as supplied by the manufacturers, are normally reduced to the required width on special purpose machines at the company's Hollinwood factory. On the West Gorton feed line (illustrated here) coils prepared at Hollinwood are loaded on to the decoiler by a loading truck. The decoiler consists of a spindle-mounted mandrel driven by a variable speed a.c. motor through a reduction gear; an electromagnetic clutch with an electromagnetic brake at the other end controls which drive a two-lift cam through a reduction gearbox and reversing clutches. The lifts on the cam rotate a magslip, the rotor output of which is fed into a phase sensitive rectifier. As the lifts are so designed that at some point zero output is obtained from the magslip rotor, rotation of the cam about this point will give a positive or negative output from the phase sensitive rectifier. This output is fed into the d.c. amplifier and the whole system forms an accurate position control servo.

Once the d.c. motor is running, it continues to do so until the cam rotates the magslip to give zero output. The cropping tool is then operated, the clutches reverse and the cam is driven in the opposite direction while the strip moves forward. The strip will move forward until the other lift rotates the magslip to give zero output. The distance between the lifts can be adjusted to give different lengths of sheet between cuts. Provision is also made in the control panel for fine adjustment to be made in the length of material to be cut. After cropping, the core laminations are carried forward to a stacking unit by a continuously driven conveyor belt. This unit incorporates two hinged doors which, in the raised position, form a run-out table surface for the laminations.

The doors are opened by the laminations passing over a micro-switch which actuates an air cylinder. The laminations fall on to a pallet. A second micro-switch is then operated which returns the doors to their original position. Later the laminations are annealed on the continuous annealing plant at the company's Hollinwood factory.



Automatic feed line for the cutting of transformer core laminations

overrun. The material is then inched from the coil and threaded beneath the "no loop" control arm into the feeding machine pinch rollers and the side guides set to suit the material width.

The motorised reel is then switched to automatic operation and the maximum reserve loop of material formed. The reel stops automatically when the loop actuates the photo-electric cell on the control unit. Then the measuring rollers of the feeding machine are engaged, and the required length of strip selected on the control panel. The initial setting-up time of the line is about ten minutes.

The automatic sequence is as follows: the material is drawn from the loop by the feed rolls which are driven by a 3 h.p. d.c. motor and passed through a pair of measuring rollers before being fed into the cropping machine. This d.c. motor forms part of a Ward-Leonard system; a d.c. amplifier provides the field for a split field generator driven by an a.c. induction motor. The generator then feeds the d.c. motor armature (the field of which is fed from a separate d.c. source) and the motor drives the rollers of the feeding machine through a step-down gearbox giving an average feed rate of 120 per minute, but 200ft per minute maximum can be obtained. As the strip proceeds to the cropping machine, it passes between a pair of measuring rollers

Particulars of New Feed-Line for Cutting Transformer Laminations

Overall length of plant (approx.)	30ft
Overall width (approx.)	9ft
Number of operators	One
Length of laminations cut	From 3½in up to 72in
Width of laminations cut	From 1½in up to 10in
Output of cut sheets :	
72in cut length	Twenty sheets per minute
36in cut length	Thirty sheets per minute
Coil loading time (approx.)	Three minutes
Initial setting-up time (approx.)	Ten minutes
Coil capacity :	
Maximum coil weight	2800 lb
Maximum outside diameter	44in
Maximum inside diameter	20in
Minimum inside diameter	15in
Maximum width	10in
Feeding machine capacity	Thickness 0·012in to 0·014in
Feed rolls	Two pairs, 4in diameter 12in face length driven through toggle type gearing, air clamped
Measuring rolls	One pair 2½in diameter by 12in face length, air clamped

INDUSTRIAL LUBRICATION EXHIBITION.—An International Industrial Lubrication Exhibition will be held in London from February 11 to 14, 1963, at the Royal Horticultural Society's New Hall, London, S.W.1. Sponsored by the journal *Scientific Lubrication*, the exhibition is designed to show every type of lubricant and lubricating equipment now in industrial use.

SHORTER REPORTS

Aluminium Mill in New Zealand

NEW ZEALAND'S first aluminium rolling mill, the Alcan Industries Limited plant at Wiri, Auckland, has been officially opened by the New Zealand Prime Minister, The Right Hon. K. J. Holyoake, and at an inaugural ceremony on November 14, the Prime Minister started a hot aluminium ingot on its journey through the mill, to open a new chapter in the history of industrial development in New Zealand. The plant has an initial capacity for the annual production of 5000 tons of aluminium sheet and plate, and will be able to meet virtually the whole of the country's present requirements. The new mill forms the New Zealand branch of the United Kingdom company, Alcan Industries Limited, and the equipment includes a complete production unit with furnaces, semi-continuous casting unit, hot and cold rolling mills, and ancillary equipment. Its main products are flat and coiled aluminium sheet, aluminium plate, various types of corrugated building sheet, circles for subsequent pressing into hollow-ware, and slugs for the production of impact-extruded items.

In a normal sequence of rolling operations in the mill, aluminium imported from Canada is first melted and alloyed as necessary in a 25,000-lb oil-fired Priest reverberatory furnace. From here the metal is passed to a holding furnace situated alongside a semi-continuous casting unit, in which the rolling ingots are cast. Before hot rolling, the ingots are pre-heated in a Gautschi electric furnace ; hot rolling is carried out on a 72in two-high Brightside reversing mill, which is illustrated herewith and in normal operations converts an ingot 8in thick to a ¾in slab. From this stage the aluminium is worked cold, the slab being rolled to finished thickness in two stages—with intermediate annealing—on a Robertson four-high reversing mill. After cold rolling the coiled sheet, according to whether coil or sheets are required, goes either to a slitter, seen in our illustration, or to a cut-up line, which consists of spools to hold the coil, a nine-roll roller leveller, an embossing machine, and a shear. Sheets for building purposes are sheared to size and then passed to a 150-ton Bronx brake press, where they are corrugated according to the profile required. Tools are available for the familiar " circular " corrugated sheet and for several patterns of full-size and miniature troughed sheets. Those sheets that are for general engineering or industrial use are flattened in a 250-ton Fielding and Platt stretcher, which is capable of handling sheets 5ft wide and 20ft long, and plate up to 1in thick. A Rhodes mechanical press is installed for the production of aluminium slugs, which are punched from sheet or plate, and of circles up to 15-in diameter. Larger circles, up to a maximum of 4ft diameter, can be produced by means of circle cutters. For small quantities, and for extra-wide sheets, there are two 84in Brightside flat sheet mills.

In addition to the usual ancillary and maintenance machinery, there is a Craven machine for roll grinding. Although as presently laid out the works has a 5000-ton annual output this can be substantially increased simply by the addition of further cold-rolling facilities, since the hot mill already has a much greater capacity than its present rating. Foundations have been prepared for a foil-rolling mill, which should be in operation by the spring of next year, and there is provision for the eventual production of aluminium wire and cable. The works buildings, which are largely clad with aluminium, cover 125,000 square feet and stand on a thirty-two acre site close to the main highway south from Auckland. The mill is housed in two 500ft by 80ft bays, each equipped with overhead travelling cranes ; these have a capacity of 25 tons in the hot mill bay and 10 tons in the cut-up bay. The remelt, motor room, stores and tool room form annexes to the main bays ; fuel storage, water cooling towers and the pump house are separate from the main building.

Spot-Welding Electrodes

THE introduction of a new series of five spot-welding electrodes, produced from ½in diameter bar with ½in tapers to B.S. 807, is announced by Johnson, Matthey and Co. Ltd., 73-83, Hatton Garden, London, E.C.1. These electrodes are intended to give better access in confined spaces and cost less than types made from ¾in bar.

High-conductivity Mallory 3 alloy is used for the electrodes. The tapers are accurately machined, and the recommended tip diameter and rake angle are provided. In accordance with the specification, the omission of spanner flats permits a larger diameter hole for cooling water. The new electrodes are available from stock.

[Reply Card No. 1443]

Cylinder Measuring Instrument

WE illustrate here a measuring instrument Thomas Mercer Ltd., of St. Albans, supplied to a Canadian publishing company for checking the diameter of photogravure cylinders. These cylinders, after having been used for a printing, are skimmed to a smaller size which has to be accurately determined. The illustration shows a gauge together with its associated setting master.

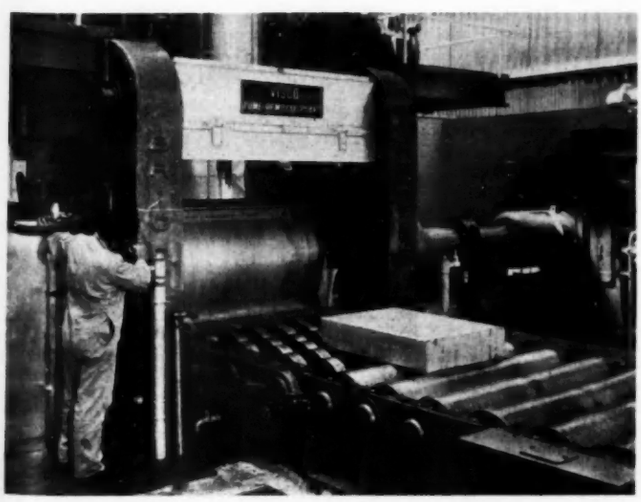
The setting master has three rollers accurately spaced to simulate the required cylinder size. The gauging body, of close grained cast iron, incorporates two tungsten carbide locating shoes

Gauging instrument for cylinders being adjusted on its setting master

and a " Precimeter " head for the gauging element.

To prepare the gauge for use it is placed on the setting master and the indicating head adjusted to give a reading either at zero or at the plus end of the graduated scale, bearing in mind the fact that all cylinders will be of the nominal diameter, or smaller. On the gauge being placed on the cylinder under inspection the difference in size between the cylinder and the master can be determined to a stated accuracy of 0·00005in.

[Reply Card No. 1479]



Two-high 72in Brightside reversing hot rolling mill

Slitter for trimming coiled sheet

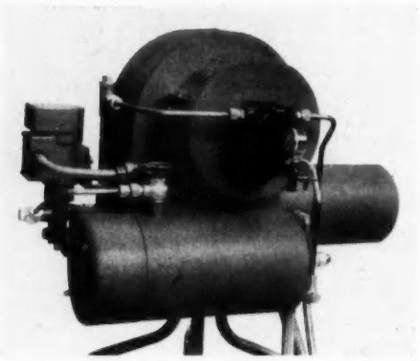
SHORTER REPORTS *(Continued)*

Residual Fuel Oil Burner

A NEW oil burner unit, called the "Senior", and designed for use with residual fuel oil having a viscosity of 200 seconds Redwood 1 at 100 deg. Fah. has been marketed by Wanson Company Ltd., of Boreham Wood, Herts.

It is specifically designed for use with air heating equipment and will be incorporated, where required, in the company's range of "Thermobloc air" heaters.

The "Senior", seen in our illustration, depends for its efficiency on good atomisation of the oil and good control of the combustion air and special attention has been paid to the control of the temperature at which the oil is atomised.



Oil burner for use with residual fuel of 200 seconds viscosity

By innovations in design, the use of a sensitive thermostat having a differential of plus or minus 1 deg. Fah., and a new control sequence, the "Senior" burner is able to maintain a very stable oil temperature, with fluctuations reduced to as low as 5 deg. Fah. Another feature peculiar to this burner is the provision whereby start-up is made on oil at an elevated temperature with provision for automatic compensation should this temperature fall too low during the hot oil circulation preceding a cold start. Some applications of the "Thermobloc" require the burner to respond rapidly to frequent calls for heat and so provision has been made whereby the control system will, after the initial start up from cold, reduce the oil circulation period automatically, and provide a quick re-start after a short idle period.

The pre-heater is mounted on the main body of the burner and results in a compact assembly with a minimum of exposed pipework. All pipe connections and the fitting of the finned heating elements to the pre-heater faceplate are made with Ermeto high pressure couplings, which permit the breaking and re-making of leak proof joints. Dowty "Bonded Seals" are used on small face-to-face joints while a heat and oil resistant O-ring is used as a seal on the pre-heater faceplate.

A system of concentric tubes provides an oil-way to the nozzle and means of warming the system and its contents by circulating hot oil prior to atomising it. A Teddington WU solenoid valve is part of this nozzle tube assembly and is used to change from oil circulation to atomisation. A limited amount of hot oil continues to circulate during atomisation and this prevents the oil supply to the nozzle from being chilled by the combustion air supplied from the burner fan. An E Sunstrand fuel pump is protected on the supply side by a metal edge strainer, the chamber for which is built into the rear of the pre-heater. This compact arrangement utilises warmth from the pre-heater to assist in the filtration of the incoming oil. A 100-mesh strainer is included in the oil-way and is so positioned that it is easily removed without dismantling other components.

The burner motor can be either single- or three-phase and the intermittently rated 10,000V ignition transformer is above normal capacity at 50mA. The new Danfoss 57G burner control unit fully complies with the current draft B.S.799 and incorporates the necessary time delay relays and photo-resistor flame detection system for the complete control programme.

Apart from flame failure protection, the pre-heater is protected against overheating by the provision of a pressure relief valve and manual re-set thermostat. A switch system is incorporated in the solenoid valve to prevent the burner from starting should this valve become jammed open.

[Reply Card No. 1483]

Pantograph Test Train

IN collaboration with the Eastern Region of British Railways, the Research Organisation of British Insulated Callender's Cables Ltd. has produced an overhead equipment test unit capable of providing current collection data at speeds up to 100 m.p.h. The unit, which has gone into service recently, comprises an instrumented coach, fitted with two pantographs, and a generator coach which provides electrical power for instruments, lighting and heating. It is similar in several respects to the unit developed by B.I.C.C. for the London Midland Region and illustrated in THE ENGINEER of January 2, 1959.

The instrument coach, or test coach, was converted at the Doncaster Carriage Works from a normal passenger vehicle so as to have a central observation dome and flat roofs at each end, both of which were fitted with Stone Faiveley A.M.B.R. pantographs (Plate 5 *ante*). Instrumentation of the coach was carried out in a siding adjacent to the B.I.C.C. Research Laboratories at Wood Lane, London. Most of the instruments are contained in an instrument panel, 12ft long by 18in wide by 6ft high, which is secured both to the coach floor and roof by anti-vibration mountings. The panel is mounted below a pantograph which is earthed to the coach and is designated the "dead" pantograph. This pantograph is used during tests when the overhead line is earthed and the test unit is being hauled by a diesel locomotive. At the opposite end of the coach is a high-voltage enclosure situated below a "live" pantograph insulated for 25kV, which is used during tests with the overhead line live and with a diesel or electric locomotive hauling the unit. Arrangements have been made for the electric locomotive to draw its power from the "live" pantograph on the test coach so that the overhead equipment is not disturbed mechanically other than by the measuring pantograph.

The quantities which can be measured and recorded are : pantograph height, acceleration, contact loss, contact pressure ("dead" pantograph only), locomotive current ("live" pantograph only), and train speed. In addition, track marks and timing marks can be inserted on all recordings. Selection for recording any combination of measured quantities is effected by means of jacks and sockets on a distribution panel on the console.

The recording facilities comprise one four-channel high-speed recorder and three two-channel plus event mark low-speed recorders. The former has a good frequency response up to 1000 c/s and the latter up to 25 c/s. All recorder charts are driven by stepping motors controlled by a stepping switch transmitter attached to a "Velodyne" unit, which receives its control signal from a tacho-generator attached to a coach axle. The chart speeds are therefore proportional to the train speed and the recordings are made on a distance basis. A track distance of 100ft is equivalent to chart lengths of 20cm and 1in on the high and low-speed recorders respectively.

Pantograph height is measured directly by a specially designed linear potentiometer, some 7ft long, driven by a lightweight glass-fibre tube attached to the pantograph-head. Strain gauge accelerometers attached to the height gauges measure the pantograph-head accelerations. Contact pressure is measured by two strain gauge ring dynamometers fitted into the pantograph-head, one at each side, the outputs being added to give the total force on the head. When running with the overhead line live, the line voltage is measured by an instrument transformer and displayed on a meter and recorded so that loss of electrical contact can be seen.

For "dead" line running, a 300V d.c. circuit is completed via the pantograph, the overhead line and earth. Loss of contact is measured by recording the voltage swing in a section of the circuit. Track marks can be inserted on all recordings either manually or automatically. A lamp and photocell unit, mounted under the coach floor and vertically below the pantograph, is arranged to operate the track mark unit from a piece of aluminium foil placed on the track. Manual insertion of track marks can be made by pressing buttons in the observation dome or on the instrument panel. The traction current taken by the hauling electric locomotive is measured by a current transformer on the connecting cable between the locomotive and the test unit.

High-Power Triode for Induction Heating

THE forced-air-cooled industrial heating triode illustrated is the BR1143 of the English Electric Valve Company Ltd., Chelmsford, Essex, which was designed specifically for a manufacturer's requirement of high output from an induction heating equipment of compact construction. Maximum anode dissipation is 20kW, and the valve can be operated with an anode voltage of 10kV at frequencies up to 10 Mc/s. The thoriated tungsten filament takes 250A at 12·5V (625A maximum at starting). Overall length of the valve is 21·375in (543mm), and maximum overall diameter over handles 14in (355·6mm).

Forced-air-cooled induction heating triode

The BR114 is used in the range of high-power induction heaters introduced recently by Delapena and Son Ltd. (THE ENGINEER, June 16, 1961, page 997). A 75kW unit of this range was used recently to harden the bore of a large cast iron diesel engine cylinder liner to a depth of 0·050in/0·070in and a hardness of 450–500 Brinell at a speed of traverse of 0·25in per second, the liner being rotated meanwhile, and the operation being followed by a water spray quench.

[Reply Card No. 1456]

SHORTER REPORTS *(Continued)*

Facsimile Equipment

WITH the extension of facsimile transmission to a wide range of industrial and business purposes, it is often found inconvenient to mount drawings or documents on a revolving drum in the scanning equipment. This method, developed primarily for handling weather maps of 18in by 22in standard dimensions, may involve cutting to size, and if several sheets are to be transmitted in succession it may be necessary to have two scanning equipments so that loading can take place on one while the other is working. Further, the drum dimensions limit the maximum size of document that can be introduced into the machine. These restrictions are avoided by the flat scanning system of the "Redifax" Alden-Facsimile equipment, now being offered for sale in all countries except the U.S.A. by Redifon Ltd., Broomhill Road, London, S.W.18, under a marketing and manufacturing agreement with Alden International S.A.

In the "Redifax" Alden-Facsimile Type 9165 transmitter illustrated in Fig. 1, the document

Fig. 1—Facsimile transmitter adjusted to take documents exceeding the width of the scanning slit

is traversed face downwards by feed rollers across a flat scanning surface in which there is a slit 19in long illuminated from underneath by six fluorescent tubes. The image is focused by the internal optical system on to a revolving scanning drum in the base of the equipment, the surface of the drum being opaque except for a clear portion constituting a single-turn helix. A photo-multiplier tube projects into the interior of the drum, and as the latter rotates in synchronism with the copy feed, the effect of the helix is that the copy is scanned line by line. The light variations seen by the photo-multiplier produce a varying electric signal, which, after amplification, modulates a carrier frequency. Transmission of the modulated carrier may be effected over telephone lines, cable links, or by radio.

Documents or drawings wider than the scanning slit can be transmitted in a number of sections. To allow this, the support system for the feed rollers is mounted on two extensible arms which, when opened out as shown, allow sheets up to 54in wide to be passed through the transmitter without folding, or wider sheets without cutting. Accurate registration of the copy with the optical system, without risk of bulges or folds such as may occur when mounting on a drum, is inherent in the flat scanning method, and the long focal length available between the scanner and the helix provides a useful tolerance.

Two carrier frequencies are available by operation of a switch, one of 1800 c/s for working at sixty lines per minute over normal telephone lines having a bandwidth of 500 c/s to 2700 c/s, and the other of 2400 c/s for 120 lines per minute transmission when a 300 c/s to 2900 c/s bandwidth line is available. Basic resolution of the system is 100 lines to the inch. Maximum speeds of sending copy depend on the bandwidth capacity of the particular means of transmission being used, but it is stated that the system has the capability of running at least at eight times the above maximum, namely at 960 lines per minute, when a suitable bandwidth of 25 kc/s is available.

At the receiver, the electrical signals conveying the facsimile information are applied to an electrode system comprising a helical wire on a rotating drum, and a straight knife edge. The chemically-treated paper passes between them, the helical wire making contact with the edge as the drum rotates. Marking of the paper is due to the electro-chemical action caused by the varying potential between the electrodes. This is the fundamental facsimile principle, and the special characteristics of the "Redifax" Alden-Facsimile system are the resilient mounting of the helix wire, and the moving knife edge. These features are incorporated in the Type 9137 receiver illustrated (Fig. 2). The resilient

Fig. 2—Facsimile receiver, showing accessibility of the quick-release electronic chassis

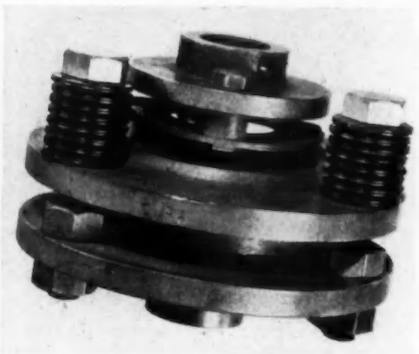
mounting of the helix compensates for small irregularities in the paper and ensures mechanical alignment and uniformity of pressure between itself and the knife edge. Since a stationary knife-edge is liable to pitting by electro-chemical action, and may need frequent replacement to ensure clear reproduction and prevent tearing, this component in the present system consists of a continuous loop of steel, that portion of the loop which coincides with the helix being constrained to lie in a straight line. The loop is driven by a small motor so as to move at the rate of $\frac{1}{8}$in per minute.

Command signals are sent between transmitter and receiver at the beginning and end of transmission, but having been started in step, synchronism is maintained by two long-term stability tuning forks which maintain their frequency with an accuracy of two parts in 1,000,000. Electronic assemblies are of plug-in modular construction, with quick-release facilities for the various chassis. Principles similar to those described are incorporated in a 2in dispatch facsimile system in which combined transmitter-receiver units are available for office installation. The 2in width of scan is based on the normal newspaper column size.

[Reply Card No. 1472]

Small Overload Slipping Clutch

WHEN introduced some time ago the "Metastream" overload slipping clutch incorporating a flexible coupling, made by Metaducts Ltd., Catherine Wheel Road, Brentford, Middx., was fitted with coil springs to impart the required loading up to the required maximum torque.



Overload slipping clutch fitted with Belleville washers

These clutches have now been modified, as shown in the illustration, and the springs have been replaced by Belleville washers, which can be placed either in parallel or series dependent on the slipping torques required. The modification has increased the capacity of the clutch, the slipping range of which is now from 0 to 110 lb inches.

The clutch has an overall diameter of $3\frac{1}{2}$in and a length of $2\frac{1}{2}$in, including the coupling, and it weighs only $2\frac{1}{4}$ lb. The clutch members of close grain cast iron are cadmium plated except for the area covered by the friction discs. A "Metastream" flexible coupling, in either single or double bank form, is incorporated to accommodate angular misalignment of shaft ends without sensibly affecting the pressure imparted on the friction plates. A slotted hub and pin through the driven shaft can be provided for variation of the shaft ends spacing.

[Reply Card No. 1481]

International Coal Preparation Congress

THE preliminary programme has now been prepared for the Fourth International Coal Preparation Congress which is to be held at Harrogate from May 28 to June 1, 1962. This congress is being organised jointly by the National Coal Board and the Coal Preparation Plant Association and by an international committee of representatives from Belgium, France, Germany, the Netherlands, and the United States.

Thirty-five papers are to be presented at the conference under seven main sections: "Relationships Between Feed Composition"; "Plant Design and Product Quality"; "Automation and Control"; "Preparation of Small Material"; "Flotation and Preparation of Fine Material"; "Determination of Washability and Separation Efficiency"; "Moisture Reduction"; and "Trends and Developments." Particulars of the conference and registration forms are obtainable from the Fourth International Coal Preparation Congress, c/o National Coal Board, Hobart House, Grosvenor Place, London, S.W.1.

SHORTER REPORTS *(Continued)*

Chemical Engineering Congress

THE Third Congress of the European Federation of Chemical Engineering will be held at Olympia, London, from June 20 to 29, 1962, and will be organised by The Institution of Chemical Engineers for the European Federation. At the same time and in the same place the Second Chemical and Petroleum Engineering Exhibition will be held, so that delegates to the Congress will be able to inspect up-to-date applications in industry. The Congress will consist of four symposia, each dealing with subjects of vital interest to the chemical fuel, fertiliser, plastic, metal extraction, synthetic fibre, rubber and food processing industries, and having the titles : "Interaction between Fluids and Particles," "Handling of Solids," "Process Optimisation," and "The Physics and Chemistry of High Pressures."

Suction Pyrometer

IN evaluating the performance of oil-fired appliances it is of importance to be able to measure the flue gas temperature. Thermometers or thermocouples inserted in the flue gas record errors ranging from 10 to 20 per cent because of radiation losses and because the gases are not thoroughly mixed before they reach the flue. To overcome this difficulty engineers at the Central Laboratories of Shell International Petroleum Company Ltd. have designed a suction pyrometer, an instrument in which flue gas is pumped at high speed over a thermocouple mounted in a shielding tube. The suction is provided by the Shell Moray Smoke Meter with which the pyrometer is designed to be used. The mineral insulated thermocouples are housed within a closed ended tubular stainless steel sheath and separated from it by an insulating refractory powder, and the outside diameter of the assembly can be $\frac{1}{16}$in., and the length practically unlimited. The unit is mounted in a $\frac{5}{16}$ o.d. by $\frac{1}{4}$in bore stainless steel tube having a bell-mouthed end extension of $\frac{3}{16}$in o.d. by 0·12in bore. The pumping capacity of the Shell Smoke Meter is about 45 cubic feet per hour, giving a cold gas velocity of 22 cubic feet per second past the thermocouple junction. This speed has been demonstrated as being adequate to give a satisfactory heat transfer from gas to couple. In use the pyrometer is connected to the smoke meter and to the temperature indicator, supplied by Evans Electroselenium Ltd., which has two scales 0 to 500 deg. and 0 to 1000 deg. Centigrade. Tests have been carried out at two levels 500/600 deg. and 800/900 deg. Centigrade, and indicate that the precision of the pyrometer is between 2 to 3 per cent of the reading. The weight of a 9in pyrometer head is 7 oz. and that of the smoke meter 9·25 lb, and the total weight of the pyrometer, smoke meter and indicator is 10·5 lb.

Diesel Fuel Additive

IT is now possible to give more detailed figures for the performance of Redex D.D. (Diesel Deodorant). A series of trials have been reported using a Gardner 1L2 engine running at 1350 r.p.m., the exhaust being sampled at high, medium and low load, first of all on untreated fuel containing 0·37 per cent sulphur and then using the same fuel with 1 oz per gallon Redex D.D. added, six hours' running being performed between adding the additive and making the observations. The results, taking two readings in each case, are tabulated below.

It will be noticed that our previous report, of a large reduction in aldehyde concentration at low powers, is confirmed ; this reduction diminishes towards insignificance at full load. In this case, however, carbon monoxide is decreased only slightly at low load. The concentration of sulphur dioxide is increased at low and reduced at high load.

Test	M.E.P. lb per square inch	Engine r.p.m.	Smoke Hartridge No.	H_2 per cent	O_2 per cent	CO_2 per cent	CO per cent	SO_2 p.p.m.	HCHO p.p.m. Aldehydes expressed as formaldehyde	
1*	12·5	1,346	11	Nil	17·1	2·9	0·025	58	51	46
2*		1,346	11	Nil	17·8	2·9	0·021	66	42	
7		1,350	10		17·5	2·9	0·028	29	63	63
8		1,350	10	Nil	17·3	2·8	0·022	45	64	
3*	60	1,354	14	0·008	16·8	2·0†	Nil	67	97	102
4*		1,353	13	Nil	12·8	6·2	0·005	57	109	
9		1,354	14	Nil	12·2	6·6	0·010	75	134	128
10		1,346	13	Nil	12·9	6·3	0·008	57	122	
5*	100	1,346	48	Nil	7·3	10·3	0·081	116	134	138
6*		1,347	48		7·2	10·5	0·072	119	142	
11		1,350	53	0·008	6·9	10·1	0·092	144	154	151
12		1,350	55	0·011	6·9	10·2	0·129	120	149	

* Tests 1 to 6 with Redex D.D. Tests 7 to 12 without Redex D.D.
† Low result disregarded.

Research on Ground Effect Machines

IT has been announced that the Ministry of Aviation has decided, in order to assist in its evaluation of the possibility of using hovercraft to meet military requirements, to institute a research programme at the Royal Aircraft Establishment at Bedford.

The Ministry is purchasing from Cushioncraft Ltd. an experimental air cushion vehicle "C.C.2," which has just been completed, to assist in the research programme. The R.A.E. will also be associated with the research programmes on the SRN.1 and the SRN.2.

The Ministry is continuing to follow closely the work which is being done in the development of hovercraft by Hovercraft Development Ltd. and the companies associated with it. Hovercraft Development Ltd. will also be associated with the R.A.E. research programme. The Ministry of Aviation is also considering the possibility of participation in other projects still in preparation.

It will be recalled that an inter-Service trials unit for hovercraft is being set up in H.M.S. "Ariel," Lee-on-Solent (see page 887 *ante*).

Improved Aluminium Production

THE BRITISH ALUMINIUM COMPANY LTD., London, and Kaiser Aluminium and Chemical Corporation, Oakland, California, have announced the joint development of a modified type of aluminium reduction cell utilising refractory hard metals as essential elements. Cells with these new cathode materials offer the first basic alteration to the electrolytic reduction process, on which the world's aluminium industry has been founded, since it was invented seventy-five years ago. This development is considered by both companies to be of major commercial significance, because it can substantially reduce the production cost of aluminium and also permit expansion of the capacity of existing facilities with relatively small capital expenditure.

An improvement of up to 15 per cent in cell operation is possible and can be achieved either by a decrease in the energy consumption per pound of metal, or by an increase in metal output per pot.

Both companies are currently using the development in certain of their reduction facilities and plan to continue making refinements in its application to existing cells in order to further the successful adaptation of the development to all types of reduction cells.

The development was invented by the research staff experts of British Aluminium Company Ltd. in the early 1950's and the Kaiser Aluminium and chemical Corporation joined, in the mid-1950's, in a joint research programme designed to carry forward the development of the basic inventions. Since then the companies have co-operated in the development of the refractory hard metal materials and their application to both existing and new electrolytic reduction cells. The refractory hard metals are chemical compounds of exceptionally high hardness and melting point and typical metals are the carbides and borides of titanium and zirconium.

Further details of the development will be given in a paper to be presented at the International Symposium on the Extractive Metallurgy of Aluminium to be held by the American Institute of Mining and Metallurgical Engineers in New York in February, 1962.

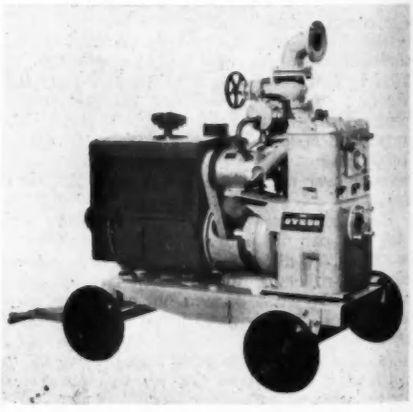
Mobile Self-Priming 4in Pump

WE illustrated below a 4in self-priming centrifugal pump, recently introduced by Henry Sykes Ltd., of 53b, Southwark Street, London, S.E.1. It is stated that this pump has a self-priming time of 13 seconds at 10ft suction and an output of 27,900 g.p.h. at this lift with nominal head. At 28ft vertical suction lift, the priming time is 58 seconds and the output is 7200 g.p.h. It can also pass solids of up to 2½in diameter as well as free flowing slurries and abrasive sludges of up to 60 per cent solids content.

In the mobile form illustrated the pump is close coupled to a Lister "SL3" air cooled diesel engine which develops 10·8 b.h.p. at 1500 r.p.m. and 12·75 b.h.p. at 1800 r.p.m. Fuel is supplied to the engine by a lift pump from a 13 gallon tank formed in the chassis, a filter being located in the line before the totally enclosed C.A.V. pump and injector. With this fuel reservoir the pump can be operated for twenty-four hours under normal operating conditions. The close coupling shaft between the engine and the centrifugal pump is fitted with a renewable hardened sleeve where it passes through a flexibly mounted pump packing gland. This gland is externally sealed by grease impregnated packing and may be repacked at any time without dismantling the pump. The pump has a three bladed impeller of impact- and wear-resistant nodular cast iron, whilst its wearing plates and casing of high grade grey cast iron allow sea water to be pumped without deterioration. Where liquids which corrode cast iron are to be handled, pump components in suitable material can be supplied.

The self priming effect is achieved by a 22 c.f.m. rotary vacuum pump, vee belt driven from the main shaft, a primary float control tank and a secondary air trap tank. By separating the self priming and pumping duties cavitation effects have been reduced to a minimum, allowing high outputs to be obtained on long suction lifts and with suction pipes of up to 500ft length.

[Reply Card No. 1425]



Mobile 4in self-priming pump designed for an output of 27,900 g.p.h. at 10ft suction and to pass solids up to 2½in diameter

Automatic Aluminising Machine for Valve Faces

PARTICULARS have also been issued by Vauxhall Motors Ltd. of a compact automatic plant which has been installed in the Luton works for aluminising the face of all engine exhaust valves, and also the inlet valves used in some of the company's engines. This plant, to be seen in our illustrations, comprises a motorised indexing table about 5ft in diameter with forty-six valve holding fixtures spaced round its perimeter. At points round the table there are a pre-heating station, where induction coils heat the valves to 500 to 600 deg. Fah. ; a flame metallisation station, where aluminium is sprayed on to the valve seats ; a reheating station, where the valves are heated to 1400 to 1550 deg. Fah. ; and a cooling section.

The valve fixtures are spaced at 4in centres round the table and each incorporates a clamping chuck designed to hold any of five different types of valves used on the engines. Valves delivered by conveyor from a cleaning plant are loaded by hand into the fixtures and are automatically clamped by the contact of a lever protruding from each fixture contacting a cam on the table framework as indexing takes place. Each fixture incorporates induction coils and is rotated by a central spindle which passes through the table and has a spur gear fixed on the lower end. On the fixture entering the pre-heating station rotation at about 500 r.p.m. commences as the gear meshes into the grooves of a driven rubber belt; at the same time electrical contacts are made through the induction unit electrodes and the valve is heated in a few seconds to 500 to 600 deg. Fah. according to its size.

On subsequent indexings of the table the heated valve is carried into the metallising station where a wire-fed metal spraying gun is adjustably mounted on the machine framework and set at the required angle to spray the valve face. Under the timing control the required amount of high purity aluminium is sprayed on the face as the valve is rotated and the table is then indexed to carry the fixture into the next station where on reheating the valve through the induction coils up to 1400 to 1500 deg. Fah. the aluminium forms a tough amalgam with the steel. Subsequently each valve is ejected from its fixture to gravitate down a chute on to a band conveyor where cooling air is blasted on to the components through a system of ducts.

At the end of the cooling conveyor the valves are visually inspected and weighed on a special balance to determine if the required weight of aluminium has been deposited. The weight of deposit varies between 0·05 and 0·07 grammes depending upon the size of the valve head.

Loading station on the valve aluminising equipment. Output is 1000 to 1500 valves per hour

Spray station of aluminising machine with wire-fed gun in operation

Fire-Resistant Building Boards

Two new vermiculite fire-resistant building boards have recently been demonstrated by Mandoval Ltd., 59, Gresham Street, London, E.C.2. (a company under the management of the Rio Tinto Mining Group). They are a vermiculite/wood fibre board and a vermiculite/asbestos/cement/wood fibre board. The first of the two boards, which is integrally flame-proofed to Class 1, B.S.476 : 1953 requirements, is already being manufactured as " Sundeala " flame-proofed fibre building board. The second is expected to be on the market shortly. Class 1 certificates have been issued in respect of the " Sundeala " board, which has been accepted as producing no flame spread whatever. When tested beyond its normal intended use, the board has remained intact as a ceramic shell after all the wood content has been consumed. In all other respects the board is equivalent to a normal fibreboard, and it can be used in the same way.

The second of the new boards, while it cannot be classed as completely incombustible, is for all practical purposes fireproof. It will withstand 900 to 1100 deg. Cent. almost indefinitely, and does not disintegrate when heated and plunged into cold water. The board is cheap to manufacture, and can be cut, nailed or screwed quite easily.

[Reply Card No. 1487]

Vibrating Screen Separator

A VIBRATING screen separator designed for continuous operation with a wide range of wet and dry materials is now being made by Sharples Centrifuges Ltd., Tower Works, Dorman Road, Camberley, Surrey. This Sharples-Kason " Vibroscreen," as it is called, is claimed to have a particularly high capacity per unit of screen mesh and immunity from screen blinding. It is at present available in one model only, with 48in diameter screens, but we understand that other models are to be manufactured at a later date. The 48in separator can be fitted with four screening decks, as shown in the illustration, to give five fractions in operation. When fewer fractions are required any one, or all, of the the three intermediate decks can be quickly and easily removed.

48in diameter vibrating screen separator designed to yield up to five fractions

The substantial cylindrical machine base supports the screen assembly and drive through spring mountings which prevent the transmission of vibration to the base and surrounding floor area. The 1 h.p. driving motor is mounted vertically at the base of the screen assembly and its double-ended shaft carries at each end an eccentric weight. The weight at the top end of the shaft is on the same axis as the screens and serves to impart the horizontal motion to the screens. The weight on the lower end of the shaft imparts the vertical motion. This lower weight can be moved round on the shaft and locked in any position, and by this arrangement the resulting component of the two motions can be adjusted to give a screening pattern best suited to the characteristics and condition of the particular material being handled.

[Reply Card No. 1480]

Polythene Bags with Fastener

WE have received from Supreme Novelty Company of Roeder House, Vale Road, Finsbury Park, London, N.4, some samples of a range of " Mini-Grip " polythene bags which it has just put on the market. The largest of these bags is 4in by an effective depth of 5½in, the smallest 2½in by 3in. The special feature which distinguishes them from similar bags is that there is inbuilt close to the opening a simple press fastener extending right across the mouth of the opening so that the contents cannot fall out. This fastener lies about ½in below the opening so that when it is desired to open the bag its edges can be grasped and pulled apart ; the effective depth quoted above is that from the fastener to the bottom of the bag. The bags may have an engineering application in the storage or packing of small parts, the more so that part of the area on one side is nearly opaque and capable of carrying a printed, typewritten or script description of the contents.

[Reply Card No. 1476]

INDUSTRIAL NEWS

National College of Agricultural Engineering

Up to twenty students will be accepted for the first three-year course, starting in the autumn of 1962, at the National College of Agricultural Engineering. The College is a new foundation, sponsored by the Ministry of Education, and established by Trust Deed in 1960. Pending completion of the College buildings at Silsoe, Bedfordshire, this first course will commence at the Mechanised Farming Centre, Boreham, near Chelmsford, which has been made available by the Ford Motor Company. When the new College premises are open, in the Autumn of 1963, residential accommodation will be available for 100 students.

The course to be commenced in 1962 will lead to the award of the College Associateship, and candidates will be expected to attain a standard equivalent to that of a general degree. The prospectus, which has now been published, contains detailed information about the College, its aims and courses.

Addressing a Press conference held in London on Monday of this week, Dr. P. C. J. Payne, principal of the College, said that until a decade or so ago the development of farm machinery and agricultural technique, though advanced, was still almost entirely dependent upon trial and error, ingenuity and intuition, and the best training a man could receive was to learn as much as possible of the practice and theory of both engineering and agriculture. But agricultural engineering, he continued, had now advanced to a point where much of it could be studied as a technology in its own right.

In the first year of the Associateship course, Dr. Payne said, the student would study the elements of engineering and agriculture as separate disciplines. This separation was both necessary and desirable, he added, because of the need to cater for a wide range of pre-entry qualifications, and because a man could not hope to synthesise the two until he had a working knowledge of each.

In the second year the study of engineering would be inclined directly towards the requirements of agricultural engineering. The study of farm machinery in the second year would be concerned with existing types of machine and plant, and how they were applied to farm production, reclamation, erosion control, &c. In the third year the analytical approach to the technology of agricultural engineering would occupy more than three-quarters of the student's time. Some aspects of economics would be studied in each of the three years.

It is also planned that the College shall offer a variety of one-year courses for men who have already qualified in agriculture or engineering. These courses, which will be "tailor-made" to the candidates' individual requirements, will enable them to specialise in such subjects as farm mechanisation, field engineering, design of crop preservation machinery, buildings, heating and ventilating, glasshouse design and farm machinery for production engineers. Consideration is also to be given to the provision of courses for candidates with less advanced qualifications.

The industry, through the Agricultural Engineers Association, has offered to give and to keep up to date a supply of its products—tractors, implements, &c.—for the work of the College. The College will work in close relationship with the National Institute of Agricultural Engineering which is also at Silsoe. Enquiries should be addressed to the National College of Agricultural Engineering, Queen Anne's Chambers, 28, Broadway, London, S.W.1.

Exports

In his presidential report to the annual general meeting of the British Council for the Promotion of International Trade last week, Lord Boyd Orr said that another £350 million worth of exports—the 10 per cent increase called for recently by the Governor of the Bank of England—could be found in the planned-economy countries, but it would require a radical change of policy on the part of the Government and a reversal of some of the practices of Government departments. Pointing out that the rate of increase in Britain's exports to the planned-economy area had been greater than the growth of its exports to any other part of the world, Lord Orr suggested that the Government was curbing not encouraging East-West trade, having adopted a policy of only "measured development."

Britain was losing markets, Lord Orr said, primarily because of a refusal to recognise that the pattern of its imports from the East must match the wider scope of its exports. Commenting on the possibility of Britain entering the European Common Market, he stated that Britain could least afford to relax her efforts in the Eastern bloc markets at a time when her principal European competitors were increasing theirs. The less Britain's immediate trade depended on the "Six," he added, the more weight would it carry in the councils of the Common Market.

Industrial Relations in the Motor Industry

Representatives of employers and workers in the motor industry met last week under the chairmanship of Mr. John Hare, Minister of Labour, for a resumption of the joint talks on industrial relations in the motor industry. At the end of the first series of talks held in April a joint statement had been issued which was to form a basis for future progress in improving relations in the industry. Mr. Hare noted with concern, at last week's meeting, the serious and lengthy unofficial disputes which had occurred in the industry since the issue of the statement.

There was, however, a noticeable feature about those strikes, he said. The employers had in no way given in to unconstitutional action and the unions had made it clear that they could not support unconstitutional action, and the result of the strikes had been nothing for the unofficial strikers but a tragic loss and suffering and similar damage for many others.

Mr. Geoffrey Rootes said that the employers felt they must make it clear that in their opinion the question of the avoidance of unconstitutional strikes was the most vital and urgent matter to which attention must be given. Referring to steps they had taken on points made in the statement, he said they had in many cases strengthened their personnel departments, extended and improved their training arrangements for junior management and in some areas co-operated with regional union representatives and education authorities in the provision of further education facilities for shop stewards. Company policies and practices in connection with consultation and communication had been reviewed and augmented where necessary. The employers were pleased to record, Mr. Rootes said, an improvement in relations at the level of the shop floor since the last talks.

Mr. W. J. Carron said that the unions fully shared the general concern about the damaging strikes in the last nine months, and re-affirmed that the unions would continue to act in accord with the spirit and intention of the joint statement agreed in April. They welcomed the steps which had been taken by the employers, he said, to secure better relationships at factory level, but would also welcome an opportunity of discussions at national level on one or two points of general principle. Mr. Rootes said that the employers would be very glad to arrange for this.

Employment

The number of people in civil employment in Great Britain, the Ministry of Labour announces, is estimated to have fallen by 11,000 to 23,997,000 during October, 1961. A decrease of 18,000 men and boys was partly offset by an increase of 7000 women and girls. In the manufacturing industries the main changes were in the motor vehicles group where the labour force dropped by 9000 to 902,000, and the engineering and electrical goods group where the number of people employed rose by 7000 to 2,171,000. In the metal manufacturing industry the number of people employed fell by 2000 to 629,000, while in shipbuilding and marine engineering the number employed dropped from 244,000 in September to 241,000 in October. Outside of the manufacturing industries, employment decreased in most industries and services, the Ministry states, except in the distributive trades and professional services where there were increases of 19,000 and 10,000 respectively. The greatest decreases were of 16,000 in miscellaneous services and 13,000 in agriculture and forestry. The Ministry points out, however, that the October, 1961, figure for civil employment is 139,000 higher than the corresponding figure for October, 1960.

In the week ended October 28, 1961, the Ministry says, the estimated number of operatives working overtime was 1,934,000, each working eight hours overtime on average. This estimate was 17,000 less than at the end of September. In the same week, the estimated number of operatives on short time was 83,000, each losing eleven hours on average. This estimate was 12,000 more than at the end of September, the Ministry states, but, on average, five hours less were lost by each worker.

PERSONAL AND BUSINESS

Appointments

MR. R. W. BAILEY has joined K.D.G. Instruments Ltd. as assistant chief designer of its pressure element department.

THE DROP FORGING RESEARCH ASSOCIATION announces that Mr. F. E. L. Copley and Mr. A. C. Hobdell joined the staff on December 1, 1961.

MR. ARNOLD CARR, deputy chairman and assistant managing director of Thos. W. Ward Ltd., has been appointed joint managing director of the company.

MR. R. E. PURDHAM has been appointed chief engineer and member of the executive of Baker Perkins Ltd., Bedewell division, at Bedewell Works, Hebburn-on-Tyne.

THE BRITISH MOTOR CORPORATION announces the appointment of Mr. C. A. Griffin as chief engineer, cars, and of Mr. George Argyle, A.M.I.Mech.E., as chief engineer, commercial vehicles.

MR. P. MCGREGOR ROSS has been appointed chief development engineer in charge of the engineering development design office of the Tube Investments' Research and Development Organisation.

MR. W. TITMUSS has joined International Rectifier Company (Great Britain) Ltd. He will be responsible for marketing semiconductor devices, including heavy-duty rectifiers for the power industry.

BRITISH EXECUTIVE AND GENERAL AVIATION LTD.—BEAGLE—announces that Wing Commander T. A. Vigors has been appointed sales director of the BEAGLE Group with effect from February 1, 1962.

FREDERICK PARKER LTD. announces that Mr. George H. Hurst, export sales manager, has retired after thirty-six years with the company, because of bad health. He has been succeeded by Mr. Antony J. Hill.

MR. JAMES FRASER has been appointed manager of the Greenock, Scotland, factory of IBM United Kingdom Ltd. in succession to Mr. A. McLeod who is now returning to Canada as assistant plant manager at the Toronto factory of IBM Canada.

THE MINISTRY OF POWER has announced the appointment of Mr. R. F. Summers to be a part-time member of the Iron and Steel Board with effect from January 1, 1962, in place of Mr. A. G. Stewart, whose appointment expires on December 31, 1961.

THE ENGLISH ELECTRIC COMPANY LTD. announces the following appointments in its aircraft equipment division, Bradford: Mr. E. B. Lynch has been appointed chief sales engineer, and Mr. C. T. Leeson has been appointed chief service engineer.

MR. R. H. G. SUTTON is retiring at the end of the year from the managing directorship of Urquhart's (1926) Ltd., after thirty-six years' service with the company. He will remain deputy chairman and will also continue as technical adviser to the British Oil Burner Manufacturers' Association. Mr. Sutton will be succeeded as managing director by Dr. W. H. Wheeler.

MR. MAURICE DOWNHAM, home sales manager of Perkins Outboard Motors Ltd., has been appointed general sales manager (outboard motor division) The Perkins Engine Company Inc., Detroit, U.S.A. Mr. A. H. Ruff, who has been sales representative of Perkins Outboard Motors Ltd. for two-and-a-half years, becomes acting home sales manager of Perkins Outboard Motors Ltd.

THE GENERAL ELECTRIC COMPANY LTD. announces the appointment, as from January 1, 1962, of Mr. A. J. Scamp as personnel director with a seat on the board. Mr. Scamp has been released by Massey-Ferguson (U.K.) Ltd., in which company he is director of personnel and industrial relations. He relinquishes his directorships of both Massey-Ferguson and F. Perkins Ltd. as from December 31, 1961.

THOMAS BOLTON AND SONS LTD. announces that in a re-organisation of its sales department as from January 1, 1962, Mr. J. G. R. Warburton will be transferred from Widnes to the Froghall Works in Staffordshire to take charge of the new department as sales manager. Upon the same date, Mr. A. R. D. Kitson will become London sales manager and will operate from 168, Regent Street, London, W.1. Both Mr. Warburton and Mr. Kitson will continue to be responsible to Mr. H. C. Walters, the company's home sales manager.

Business Announcements

CRABTREE ELECTRICAL INDUSTRIES LTD. has opened new London showrooms at 230, Tottenham Court Road, London, W.1.

E.M.O. INSTRUMENTATION LTD., Western Road, Bracknell, has announced that its name has been changed to The Barden Corporation (U.K.) Ltd.

THE GENERAL STEEL AND IRON COMPANY LTD. has opened new offices at 30-32, Mortimer Street, London, W.1. (telephone, Langham 4741 (ten lines)).

DOWTY ROTOL LTD. announces that, as from January 1, 1962, the address of the company's service department will be Cheltenham Road, Gloucester (telephone, Gloucester 24431).

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS, and ELECTRICAL ENGINEERS (A.S.E.E.) EXHIBITION LTD. are now at 26, Bloomsbury Square, London, W.C.1 (telephone Langham 5927-8-9).

THE DISTILLERS COMPANY LTD. states that the engineering division headquarters has been transferred from Devonshire House, Piccadilly, to Enford House, 139-151, Marylebone Road, London, N.W.1.

STANLEY WORKS (G.B.) LTD. announces that, subject to Treasury consent, it has agreed to purchase from John Brown and Co. Ltd., and from the minority shareholders, all the shares in the power tool firm of S. N. Bridges and Co. Ltd.

VICKERS LTD. announces that it is completing negotiations for the acquisition of 60 per cent of the equity in All Wheel Drive Ltd., Camberley; the balance of the shares, 40 per cent, will be held by Clark Equipment International.

JACK OLDING AND CO. LTD. announces that as from January 1, 1962, it will be responsible for the sales and service of the Michigan range of tractor shovels, 'dozers and motorised scrapers in fifty counties throughout England and Wales.

ASSOCIATED ELECTRICAL INDUSTRIES LTD. announces that an office of the Midland Region of the home district office division has been opened at Alma Street, Coventry (telephone, Coventry 24181). Mr. R. C. Jenkin has been appointed manager.

THE JOHN FOLKES GROUP LTD. has acquired the whole of the issued share capital of British Industrial Tool Supplies Ltd., which carries on the business of manufacturing drop-forgings at its freehold premises in Dudley Road, Lye, Near Stourbridge.

PLESSEY NUCLEONICS LTD. and the KAMAN AIRCRAFT CORPORATION (NUCLEAR DIVISION), Colorado, U.S.A., have concluded an agreement whereby Plessey Nucleonics Ltd. will market Kaman "Pulsatron" pulsed neutron generators throughout Great Britain and the Commonwealth.

MR. N. L. PIGACHE has been appointed general manager of A.P. Green Refractories Ltd. (formerly A.P. Green (Great Britain) Ltd.), with effect from December 1, 1961. The company announces that it is extending its range of speciality refractory products to cover all the requirements of high temperature work.

THE TEDDINGTON GROUP OF COMPANIES announce that, as from November 27, 1961, the gauging divisions of Teddington Industrial Equipment Ltd. have been transferred as a unit to Teddington Aircraft Controls Ltd., and that all correspondence regarding "Teddington" air gauges should be sent to: Teddington Aircraft Controls Ltd., Cheapside Chambers, Cheapside, Reading, Berks. (telephone, Reading 55235).

HORSTMAN LTD., a subsidiary of the Simms Motor and Electronics Corporation Ltd., is operating in new premises at Bath which were formally opened by Lord Hylton, Lord Lieutenant of Somerset, on December 8. The new works, in Lockwood Road, is primarily an assembly plant, relieving from this work the company's machine shops at James Street. A floor area of 37,200 square feet has been provided and a staff of some 400 is employed, but the company hopes to pursue the development of the whole of the Lockwood Road site of 5 or 6 acres, envisaging work eventually for 4000 employees.

POLLARD BALL AND ROLLER BEARING COMPANY LTD. has announced the formation of the Pollard Ball and Roller Bearing Corporation, with registered offices at 521, Fifth Avenue, New York, 17, N.Y. This development gives the Pollard organisation, with its Canadian subsidiary, facilities for further extending the company's ball and roller bearing business throughout the United States and Canada. Mr. J. L. King, chairman of the Pollard Ball and Roller Bearing Company Ltd., is president of the corporation. The resident director is Mr. F. W. Herlitz, director of the Western Steel International Corporation in New York.

W. H. DORMAN AND CO. LTD. states that Mr. J. W. Whimpenny has, at his own request, resigned the position of managing director and his resignation has been accepted with regret with effect from December 31, 1961. Arising from this, Mr. L. Johnson, development director, has been appointed director and general manager as from January 1, 1962. Mr. W. E. Mitchell and Mr. B. A. Wilford remain, as hitherto, design director and commercial director respectively. In order to achieve maximum benefit out of the association of Dormans with English Electric, it has been decided to integrate the selling organisation of Dormans with that of The English Electric Company's Diesel Engine Division and Mr. I. MacLeod-Smith, while remaining a director of Dormans, is appointed joint sales manager of The English Electric Company's Diesel Engine Division. As from January 1, 1962, Mr. Darby Haddon resigns from the board of W. H. Dorman and Co. Ltd., and Mr. H. M. Mathews joins the board. Mr. Mathews is director of engineering of The English Electric Company Ltd.

Contracts

BRUCE PEEBLES AND CO. LTD., Edinburgh, have received from the Transmission Project Group of the C.E.G.B. an order worth over £320,000 for two outdoor, closed-hydrogen-circuit, water-cooled, 60MVAr, 13kV, 1000 r.p.m., salient-pole synchronous condensers for installation initially at West Weybridge. The condensers will be capable of negative (i.e. under-excited or inductive) operation at an input rating of 30MVAr, and auto-transformer starting will be employed. They will be specially designed for complete erection on site (and, if subsequently required, for dismantling and re-erection elsewhere) without the use of an overhead crane; neither heavy excavation work nor elaborate foundations will be necessary.

ASSOCIATED ELECTRICAL INDUSTRIES LTD. has received from Electrical Drive Applications Ltd., London, an order worth £182,000 for the supply of electrical equipment on nine Crabtree double-width printing presses for the *Birmingham Post and Mail*. The equipment will be installed in the newspaper's new premises, which will face the redeveloped Snow Hill Station in the Colmore Circus area of the city. Initially, each of the nine presses will comprise five black-and-white printing units, one late news section, two full colour decks, and a double folder geared for a maximum output of 50,000 copies per hour. Ultimately, each line will be increased to nine black-and-white printing units, one late news section, four full colour decks, and a double folder.

The initial order provides for thirty-six totally-enclosed, closed-air-circuit, compound-wound direct-current motors rated at 100 h.p., 850/1700 r.p.m. continuously and intermittently rated to 850/26 r.p.m., complete with "Perigrip" a.c. brakes. These motors will be electronically controlled from thirty-six cubicles, each complete with air-cooled, full-wave silicon rectifiers and saturable reactors, to be supplied by the A.E.I. Electronic Apparatus Division, Leicester. Nine cubicles will house the magnetic amplifiers for controlling the d.c. windings of the saturable reactor and the variable-voltage field supply of the motors.

Deaths

IT is with regret that we have to record the death at the age of seventy years, of Mr. Frank Thompson-Schwab, chairman of the Darwins Group of Companies and of Balfour and Darwins Ltd.

WE have learned with regret that Mr. George W. P. Page, A.C.G.I., A.M.I.E.E., who until his retirement at the end of 1953 was a member of the staff of the publicity department of the then British Thomson-Houston Company Ltd., Rugby, died on Saturday, December 2, 1961, at St. Albans General Hospital. He was seventy-two. George Page was born in London and was educated at Enfield Grammar School and Finsbury Technical College. After gaining practical engineering experience in industry he took a course in electrical engineering at the City and Guilds of London Institute Central Technical College. For a short time he lectured at Bristol University, and later was an assistant on the editorial staff of *Electrical Engineering* before joining the publicity department of The General Electric Company Ltd. He entered the service of B.T.H. in December, 1923.

CONTINENTAL AFFAIRS

by Our Continental Editor

Maracaibo Bridge

Incorporating five spans of 235m—the longest concrete girder spans to date—the almost 8700m long Maracaibo Bridge is now nearing completion. Carrying a major four-lane motorway across the straits connecting Lake Maracaibo and the Caribbean, the new bridge will give ample clearance to tankers on their way to and from the important Venezuelan oilfield which lies at the head of the lake. One hundred and thirty-five spans of six different sizes are employed, resting on tall trestle piers. The shorter spans are bridged directly with prestressed concrete girders while in the case of the longer spans, the same beams are suspended between cantilever sections resting on the piers. The wide use made of standardisation and prefabrication has greatly contributed to the speed of construction.

ONE of the world's major oil deposits lies under the southern part of Lake Maracaibo in Venezuela. This lake lies west of the capital of Caracas and only a short distance east of the provincial capital of Maracaibo (population 600,000). Here the coastline of the Caribbean is interrupted by an approximately 9km wide inlet behind which the lake extends inland for about 200km. Some 80km wide at its widest point, it covers an area of 16,800 square kilometres with a comparatively shallow sheet of water only 12m to 15m in depth. This, however, is adequate for the oilfield to be reached by ocean-going tankers.

For the Pan-American Highway which here follows the coast, the lake constitutes a major obstacle, necessitating the use of ferries if an extensive detour inland is to be avoided. A few years ago the Venezuelan Government instituted a design competition for a combined railway and road bridge over the Maracaibo straits. This bridge was to have incorporated a free central span of 400m with a vertical clearance of 45m, flanked by five spans of 150m at the same height above the water. The remainder of the bridge was left to the designer's discretion.

The proposal selected for carrying into effect was that of Professor Riccardo Morandi, who suggested a design in prestressed concrete. In the past, only steel would have been considered for girder spans of this size. Under the prevailing climatic conditions, however, the cost of maintaining the steelwork in good condition would have been very high. It was this circumstance which led to the idea of a concrete bridge in the first instance which eventually won the day.

Professor Morandi's concept was to subdivide the central span into two cantilever sections and one suspension span in the middle. This would have brought the size of the component members within the range of past experience.

Before work could be started the government was overthrown, and the new government decided to modify the scheme in the interest of economy. The railway crossing was dropped, and the specification now called for a total of four lanes of roadway of 3·6m width each and two 0·9m wide footpaths with a 1·2m wide central reservation. A complication was the requirement to carry three water mains of 0·65m diameter, which amounted to some 25 per cent of the useful load.

According to the revised specification the shipping channel was to be spanned by five spans, each 235m long, which were to be flanked on either side by one span of 160m long, and, respectively, eleven and fifteen spans of 85m, followed by another 65·80m span. Details may be seen from the following Table. From the western abutment at Punta Piedra, the bridge rises continuously from 14·40m above sea level datum to 50·00m at km. 1·536, with a gradient of 2·47 per cent. Over the five centre spans, and one half of each of the adjoining 160m spans, the deck is horizontal, and thereafter slopes down again at a gradient of 2·47 per cent to a point 17·20m above datum, approximately 4300m along the bridge, where the slope reduces to 0·40 per cent.

TABLE—*Layout of Maracaibo Bridge*

Between Punta Piedra (western end) and Punta Iguana (eastern end)

One span of	22·60m	Total	22·60m
Two spans of	46·60m	,,	93·20m
One transition span of	65·80m	,,	65·80m
Fifteen spans of	85·00m	,,	1275·00m
One transition span of	160·00m	,,	160·00m
Five spans of	235·00m	,,	1175·00m
One transition span of	160·00m	,,	160·00m
Eleven spans of	85·00m	,,	935·00m
One transition span	65·80m	,,	65·80m
Seventy-seven spans of	46·60m	,,	3588·20m
Twenty spans of	36·60m	,,	732·00m
Dam	—		406·00m
		Total	8678·60m

The section between the 7km-mark and the eastern end of the bridge at Punta Iguana is horizontal and 5·5m above datum. The last 406m are formed by a dam. Our illustrations Figs. 1 and 2 give an impression of the bridge during construction.

Over the main spans the depth of water reaches 17m in places, elsewhere it is mostly 10m to 12m, with a minimum of about 2m over the length of the dam. The lake floor consists of sandy mud, while the deeper layer is formed by increasingly solid sand. Firm subsoil—defined as subsoil capable of resisting twenty blows in the standard penetration test, and fifty blows 4m lower down—was encountered at depths varying from about 30m below sea level datum under the channel, to 45m below datum around the 6·7km-mark. At both ends, the soil is firm at a depth of 10m or less.

The bridge was projected to conform with United States Highway Standard Specifications, since many of the vehicles for which it is intended are built in accordance with those standards. As a protection against damage in war, the bridge is capable of withstanding the destruction of one span without collapsing. Horizontal and longitudinal wind loads were taken to be 250 kg per square metre for the empty bridge, and 150 kg per square metre for the fully laden bridge. Braking forces were assumed to total 20 per cent of the maximum traffic load, disregarding vibration.

Daily and annual temperature fluctuations are small. A temperature gradient of 5 deg.

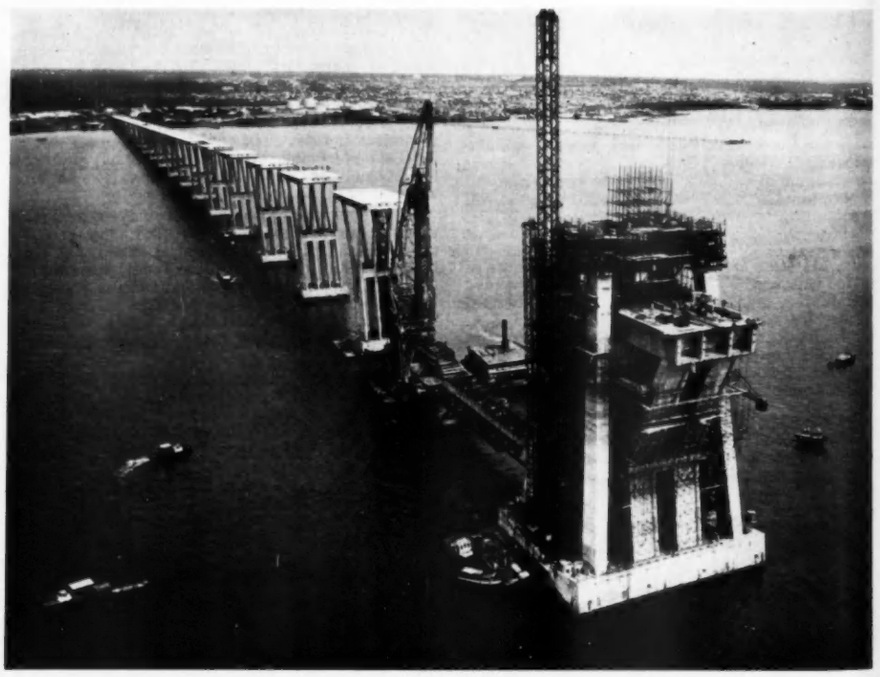


Fig. 1—View towards Punta Piedra, showing the 85m spans nearing completion, and work proceeding on one of the piers for the first main span of 235m. A 250-tonne floating crane with a lift of 50m (since increased to 75m) is seen at work erecting a section of centering

Cent. across the deck was assumed in the calculations, also a temperature change of ±10 deg. Cent. in the piers of the 85m spans, and a rise of 20 deg. Cent. in the tie members of the 235m spans. Shrinkage of the concrete was taken to be equivalent to a drop in temperature of 18 deg. Cent.

For prestressing, use is made of the Italian system (Morandi System). The cables consist of multiples of three wires, as the wires are anchored in groups of three.

The main and cross girders are prestressed with 70-tonne cables consisting of eighteen wires of 7mm diameter held by six conical anchors, while the deck is laterally prestressed with 35-tonne cables. Wires are of basic Siemens-Martin steel with 0·8 per cent carbon ; having 150 kg to 170 kg per square millimetre ultimate strength, they are subjected to initial and final stresses not exceeding 120 kg and 90 kg per square millimetre.

The concrete is specified to have a strength of 450 kg per square centimetre at twenty-eight days, and compressive stress is limited to 189 kg per square centimetre for short spells during assembly, and to 144 kg per square centimetre permanently.

Fig. 2—Dam section and minor spans towards Punta Iguana; with a combined length of about 4300m, these spans constitute nearly half the total length of the crossing. Their economic construction, achieved by standardisation and prefabrication, were a major factor in keeping costs down

Foundations

Piled foundations for the piers vary in accordance with the depth of the water and of the firm subsoil underneath the mud.

In the shallow zones near the shores it was decided to use normal prefabricated piles of a maximum safe bearing capacity of 300 tonnes. For the deeper foundations, special piles of 500 to 700 tonnes capacity had to be used. These were constructed by driving a 1·35m-diameter steel sleeve into the floor of the lake, on occasions to a depth of 45m below datum. A prefabricated hollow pile with 0·18m-thick walls, and of slightly smaller diameter than the sleeve, was then introduced. After withdrawing the sleeve, the space between the pile and the ground was injected with cement grouting.

Each group of piles is capped by a heavy concrete slab so as to distribute evenly the forces exerted by the superstructure.

Spans

Short Spans.—All the 46·60m and 36·60m spans, which together constitute over half the actual bridge, are supported on piers which comprise four reinforced concrete walls 0·60m thick and spaced with centres 4·11m, 3·90m and 4·11m apart. The width tapers from 3·53m at the base to 1·60m at a " waist " 6m below the deck, after which it expands again. At the top the pier walls are joined by a tee-section transverse concrete girder 1·1m deep. This beam supports the deck spans which are formed by four prefabricated tee-section girders spaced at centre distances of 4·50m. Their depth varies in accordance with the span, being 2·44m at mid-span in the case of the 46·6m spans, and 2m in that of the 36·6m spans.

The webs have a thickness of 0·22m and broaden to 0·72m at the tension edge which contains eighteen cables with a total of 300 wires of 7mm diameter.

By heavy transverse prestressing—one 35-tonne cable every 0·5m—it has been found possible to give the deck a thickness of only 0·27m near the root and 0·17m towards the edge of each girder-element. A 5cm thick black top is being applied to form the road surface.

The main girders, which weigh up to 150 tonnes apiece, are put in position by a 250-tonne " Demag " floating crane.

85m Spans.—The 85m spans are supported on trestle piers, each comprising four " H "-shaped elements which rest with their legs on two 16m by 4·55m by 3m thick pile caps tied together by four heavy reinforced concrete beams. These " H "-supports, which are clearly seen in our illustration Fig. 4, are joined together approximately halfway up, and also at the top where their arms spread 20m apart and support a 39·05m long prestressed deck, bearing a 9·525m long cantilever on each side. A 45·95m long suspended section identical in design to that used for the 46·6m span completes the span of 85m.

235m Spans.—The five 235m spans are the longest girders in prestressed concrete up to the present time. In order to achieve an economical design, the whole span is divided into a 189·05m long cantilever portion, while a suspended span constructed of the same prefabricated members used for the 85m and 46·60m spans bridges the remaining 45·95m.

In view of the weight of the structure, the foundations for the long spans comprise an array of 6×6 concrete piles of 1·35m diameter and 700 tonnes capacity. They are capped by a concrete slab 34·60m wide in the direction of the bridge, and 39m in the transverse direction, with a thickness of 4·7m over the central portion sloping up to 5·90m at the fore and aft edges.

On this base stand the bridge pier and tower, two independent structures, the first comprising two sets of four " X "-frames, the second a four-legged structure of two inclined " A "-frames linked at the top by a common transverse girder (Fig. 3).

The cantilever span is formed by a continuous girder 189·05m in length with its deck 50m above the water. It is supported at points 79·52m from the centre by cables suspended from the top of the 92·50m high tower.

The cantilever girder is a triple box section, 5m deep and 14·22m wide, with the 17·40m wide deck overhanging at the sides. The webs are 0·6m thick over the piers, and 0·25m thick farther out ; the deck tapers on its underside from a thickness of 0·27m over the webs to 0·17m halfway between them, while the bottom plate has a uniform thickness of 0·20m. Connection with the pier members, which are spaced

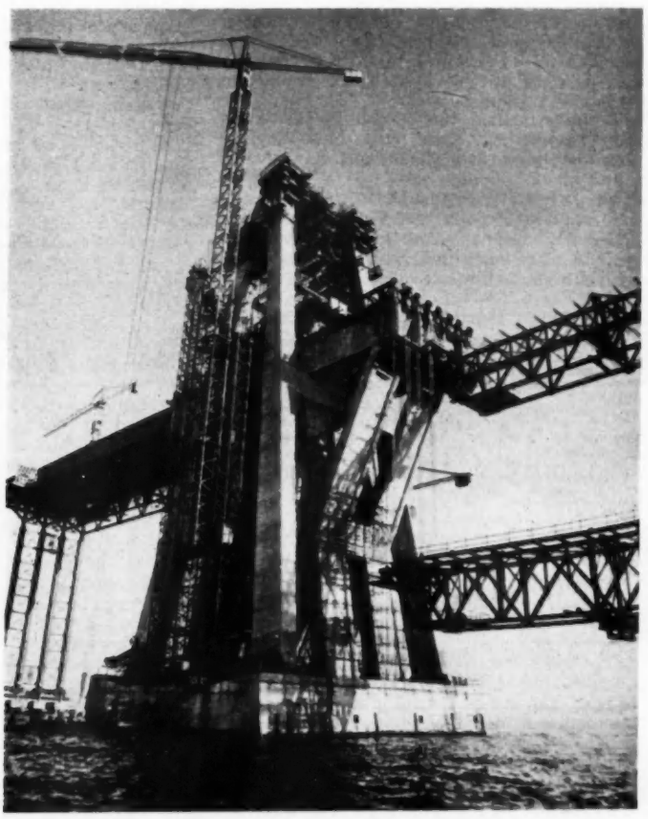


Fig. 3—Pier and tower of one of the main spans under construction. The centering for the cantilever span is already being positioned

CONTINENTAL AFFAIRS *(Continued)*

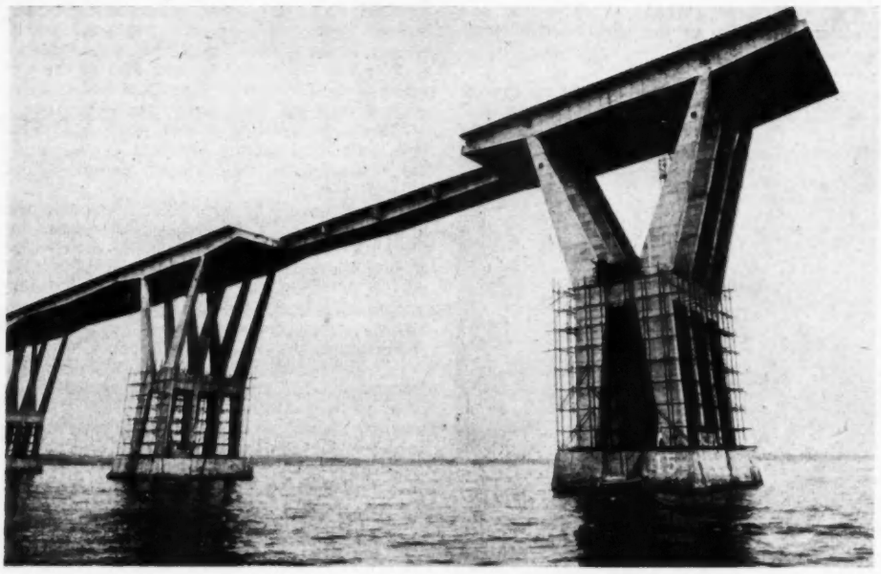


Fig. 4—85m span with one half of the deck placed in position, comprising two pre-assembled prestressed girders

directly under the webs at centres of 4·65m, 4·67m, and 4·65m, is made by substantial cross walls sloping in the direction of the pier members.

The deck is supported by a total of four suspension members, each comprising sixteen patented wire ropes and transmitting a load of 150 tonnes. The suspension cables are anchored in 22·5m long prestressed transverse girders whose section lies with its long axis in the direction of the suspension.

Construction

In the case of the 36·6m spans towards Punta Iguana, the prefabricated bridge girders were assembled two at a time on special pontoons and floated into position on their abutments. In this way, the only concrete poured *in situ* was that for the centre of the deck, after the transverse prestressing cables had been put into place and tensioned.

A similar method was followed for the 46·6m spans, except that cranes had to be used to raise the beams from the floats on to their supports.

All the piers are poured *in situ*, using metal shutters on tubular steel centering. For the large beams of the major spans special trussed steel centerings are being used which are being suspended from the towers by temporary tie rods.

Design and Main Contractors

Design : Professor Riccardo Morandi, with Messrs. C. Cherubini, H. Hofacker, E. Gabreilli, S. Scalesse, and V. Scalesse.
Control of design on behalf of Venezuela Government : Professors Stüssi and Schnitzer, Swiss Federal Polytechnic Zürich.
Consultants for foundations : Professor Kerisel, Paris.
Model tests : Laboratorio Nacional de Engenharia Civil, Lisbon ; Polytechnic Institute, Turin ; ISMES Institute of Models, Bergamo.
Main contractors : Precomprimida S.A., Caracas, and Julius Berger, Wiesbaden, with Grün & Bilfinger, Mannheim ; Philip Holzmann, Frankfurt (Main), and Wayss & Freytag A.G., Frankfurt (Main).

French Exhibitions in 1962

Among the chief industrial and engineering trade fairs and exhibitions to be held in France next year are the following (addresses of organisers in brackets) : Salon International des Composants Electroniques (International Electronic Components Exhibition), Paris, February 16 to 20 (23, rue de Lubeck, Paris 16e) ; Salon Internationale de la Machine Agricole (International Agricultural Machinery Exhibition), Paris, March 6 to 11 (95, rue St. Lazare, Paris 8e); Salon International de la Chimie (International Chemical Exhibition), Puteaux, April 25 to May 4 (28, rue St. Dominique, Paris 7e ; Butlers Advertising Service, 292, High Holborn, London, W.C.1. Tel.: CHAncery 4224-5) ; Salon International du Materiel de Travaux Publics et du Batiment (International Building and Public Works Equipment Exhibition), Le Bourget, May 17 to 27 (1, avenue Niel, Paris 17e ; Exposition Internationale des Plastiques (International Plastics Exhibition), Paris, May 19 to 29 (10, rue du Mont-Tabor, Paris 1er ; M. Neven du Mont, 18, Queensberry Place, London, S.W.7. Tel.: KENsington 1700) ; Biennale Française de la Machine-Outil (French Machine Tool Exhibition), Puteaux, May 25 to June 3 (40, rue du Colisée, Paris 9e) ; Biennale des Industries Mécaniques et Electriques et de l'Equipement de l'Usine (Engineering and Electrical Industries and Factory Equipment Exhibition), Puteaux, May 25 to June 3 (40, rue du Colisée, Paris 8e) ; Salon de la Radio et de la Television (Radio and Television Exhibition), Paris, September 13 to 24 (23, rue de Lubeck, Paris 16e) ; Salon International de l'Emballage (International Packaging Exhibition), Puteaux, September 15 to 24 (40, rue du Colisée, Paris 8e) ; Salon International de l'Automobile du Cycle, du Motocycle et des Sports (International Motor and Cycle Show), Paris, October 4 to 14 (Grand Palais, Porte J, Paris 8e ; R. C. Liebman, 178, Fleet Street, London, E.C.4. Tel.: CITy 5889).

Utrecht Fair

Next year's International Spring Trade Fair at Utrecht will be held from March 12 to 20. Two-thirds of the total exhibition space will be occupied by building and transport material. This show, which is held biennially in alternation with the Engineering and Marine Exhibition, will include equipment for use in house construction, road-building, hydraulic engineering, mining, and earth-moving. Among other industrial plant and machinery will be internal combustion engines, pumps and compressors. In addition to the technical section, which will be housed in the enlarged Croeselaan halls, a wide range of consumer goods will be on display on the Vredenburg site.

The 1962 Utrecht programme includes an international plastics exhibition " Macro Plastic " (October 18 to 25), and during November 21 to 28 the " Machevo," a specialised trade fair for manufacturers, importers and distributors for machinery, laboratory equipment, and supplies for the food, luxury goods, dairy, chemical and pharmaceutical industries.

Portable pH-Meter

A portable pH-meter, the Model " G.E.T. " by Ludwig Seibold, Vienna I, Wipplingerstrasse 24 (Agent : H. G. Stevens Company Ltd., 16, Coverdale Road, London, N.W.2) permits instantaneous readings to be taken in vats, tanks, and small or deep vessels. The shock-resistant electrodes can be cleaned easily, it is stated, which may be necessary, for example, if fats or greasy substances have adhered to them. Our illustration shows the instrument, which

Portable pH-meter

has a range of 2 to 12 pH with an accuracy stated to be ±0·1 pH (or ±0·05 pH if specially calibrated). Controls comprise a combined switch and calibration knob, temperature control knob, and means for setting the pointer to correspond to asymmetry potential of electrode. The 30mm-diameter immersion section is made of " Plexiglass." It contains a single-bar measuring assembly, with high resistance glass electrode protected by a " Plexiglass " cover which for storage is replaced by a solid thimble. The overall length of the instrument is 495mm. It is operated by standard type batteries housed in the 45mm diameter shaft.

[Reply Card No. 1410]

Computer for Oil Operation Problems

A large and up-to-date computer system is now in operation in the central offices, in The Hague, of the Royal Dutch/Shell Group of Companies. It consists of an I.B.M. 7070 computer coupled to a smaller I.B.M. 1401 " satellite," and processes a vast and varied amount of information needed in the companies' oil and chemical operations in Holland and elsewhere. The applications of the new system are many, and at present include planning and design of new refinery and other plant, elaboration of exploration data, calculations connected with laboratory research work, financial reporting and administration of wages and salaries. The 7070/1401 system, which replaces an I.B.M. 650 computer installed in 1958, is more versatile and faster than the latter, and has a better " memory," 10,000 " words " of ten " positions " for the 7070 and 4000 " positions " for the 1401, against 2000 " words " of ten " positions " for the 650. The two new machines are smaller, partly because they incorporate transistors, and do not require additional office space.

Housing Construction in Sweden

INVESTMENT in housing in Sweden amounts to some 4500 million Skr. (£1500 million), a sum equal to approximately 35 per cent of the total spent on all kinds of building and construction. Last year 68,000 dwelling units were built, almost 25 per cent consisting of houses for one and two families, including terrace houses, while 75 per cent were blocks of flats.

In spite of this intense building activity, which has been in progress for some time, Sweden suffers from a considerable housing shortage, due mainly to the migration of people from the country into the towns and the rising standard of living. The building industry finds itself confronted by a scarcity of labour and high wages, and in order to meet this situation has rationalised and mechanised itself to a high degree. The principal building methods now in use have mostly been developed by contractors in co-operation with a few important manufacturers of building materials, consulting engineers and architects.

Fig. 1—Flats at Nasbydal, north of Stockholm, under construction by the " Skarne " system

In the " Skarne " system (Figs. 1 and 2) an *in situ* concrete tower is constructed with sliding formwork. This constitutes a central core around which the rest of the building is erected ; it acts as a stabilising element of the building and contains all the services, stairs, and lifts. In general, the internal walls are load-bearing, while the external walls—often made of " Siporex " lightweight concrete—are not.

Another system is the " All-Concrete " which consists of a monolithic arrangement of *in situ* concrete cross walls and floors. The main point about this system is the prefabrication of the formwork, which is made up in wall-sized panels consisting of two leaves with a platform at the top from which the workman pours the concrete. These panels are positioned by crane and are easily removable afterwards. Floors are similarly cast with prefabricated forms on retractable legs.

The " Sundh " system is based on wall-sized precast slabs comprising two leaves of concrete with insulation between ; bathrooms are precast as a complete box with provision for plumbing and services.

Another development is that of the " Corpus " building method by A.B. Skånska Cementgjuteriet, in which a precast concrete unit—the " heart "—is delivered to the site complete with plumbing, heating, and cooking installations. The firm recently completed by this method a single-storey house of over 800 square feet floor space in four days ; it took only 13½ hours (from 6 a.m. to 7.30 p.m. on the same day) to erect the walls and put the roof into position. The main structure is of concrete, the walls having a thickness of 6cm, and floors and ceilings one of 10cm. Heating coils are precast into the flooring. Internal partitions consist of two leaves of 6cm thick concrete with an air space of 15mm between to provide sound insulation. External walls are lined with 10cm of rockwool insulation and clad with precast concrete panels, brick, wood or other material specified.

Each element is placed on four low concrete plinths, one at each corner, and positioned by adjustable screws. Since the exterior wall element includes a base panel, no special foundation is needed. Instead, the space between the plinths is covered with a thin layer of concrete macadam and a 20cm layer of rockwool. The roofing is made up of six prefabricated elements. A module system is applied throughout, leaving a large measure of freedom in specifying the sizes of the rooms, the dimensions of the elements being restricted only by considerations of transport.

Cellular lightweight concrete developed by International Ytong A.B. is now available in the form of precision blocks which may be locked together by means of polystyrene discs inserted in grooves milled into the upper and lower surfaces. These grooves, 3mm wide and 20mm deep, are accurate to within ±0·2mm. While previously blocks were joined with glue, the new kind of joint does not have to be glued. Cellular concrete gives a high degree of thermal insulation. In the case of loaded walls, the lack of tensile strength of the dry joints is no problem, but internal partitions, for instance, have to be stabilised using the longitudinal grooves to reinforce the walls. In the case of single-storey buildings, the roof can be anchored by concealed vertical tie-rods. The absence of glue or mortar makes the method particularly attractive for winter construction.

As a result of the use of high precision structural elements, finishing operations have been simplified. Thus, plaster can be very thin and as a rule is sprayed on as a single coat. Factory-made façade elements of coloured coarse-ground materials bonded with acrylic plastics are now available for all kinds of lightweight concrete elements.

Sweden being a country rich in timber, about 65 per cent of the one- and two-family houses are wooden structures. Economical forms of framework construction have reduced timber requirements to about 0·07 cubic metres per square metre (2 cubic feet per square yard).

Fig. 2—After the core has been constructed, the load-bearing internal walls and floors are cast *in situ*. The outer walls frequently consists of non-load-bearing slabs of lightweight concrete. This illustration shows blocks of flats at Arsta, south of Stockholm

First Turbine Commissioned at Bratsk

On November 28, the first of twenty 225MW generators of Bratsk Power Station was officially commissioned. Completion is scheduled for 1963 when the full installed capacity of 4500MW is to be attained. The station, which was begun in 1955, will be the largest hydro-electric power station in the world. It lies on the river Angara, which drains Lake Baikal and flows into the Yenisei. The mean annual flow is 92,000 cubic hectometres, the mean rate of flow 2918 cubic metres per second, and the ratio between highest and lowest annual flow rates is 10·5. By impounding the river to a head of 101m by means of a hollow gravity dam 127m high and 806m long, flanked by earth dams totalling 3650m and smaller concrete dams totalling 666m, a reservoir of 179,000 cubic hectometers total volume and 50,000 cubic hectometers useful volume is being created. Annual generation at 1,000,000kWh will be about half as much again as the combined output from the two largest Volga stations at Volgagrad (Stalingrad) (1951–61) and Kuibyshev (1951–57).

The power of the rivers Angara and Yenisei as far as their confluence is to be exploited by nine power stations, of which the first, a group of three stations at Irkutsk just below Lake Baikal, were built in 1948–56. At present under construction is the power station of Krasnoyarsk on the Yenisei which was to have been equipped with ten 500MW generators, but is now to have twelve generators of 800MW unit capacity, giving a total installation of 9600MW, over twice as much again as Bratsk will be. This, it is stated, is to be achieved without any increase in the size of the power station building. The total cost, it is estimated, will be only one-half that of the recently completed Volgagrad station. Generating costs it is claimed will amount to 0·03 kopecks per kilowatt hour, which would make it the cheapest electricity in the world.

Four hundred and eighty kilometres upstream from Krasnoyarsk is the Sayany Corridor, a gorge cut by the Yenisei through the Sayany range. Work on a power station at this site is to begin during the current seven year plan (1959–65). This station also will have 800MW turbines and a dam about 200m high.

THE AMERICAN SCENE

By Our American Editor

Phase-Equilibrium Studies in Metallurgical Systems

To obtain a fundamental understanding of the behaviour of metal and alloy systems, the National Bureau of Standards has been conducting research on phase equilibria. By organising data in comprehensive phase diagrams, generalisations can be made regarding other compositions in a specific system and possibly in related systems. Applications of this research on phase equilibria range from high-temperature alloys and precise gauge blocks to dental amalgams.

A better understanding of the fundamental nature of metal and alloy systems is resulting from research on phase equilibria at the National Bureau of Standards, Washington, D.C. In general, these studies are concerned with the effect of varying environmental conditions, such as temperature, pressure, and concentration of components, on the stability and chemical composition of coexisting phases—liquid or solid—in a heterogeneous system.

Each phase in a heterogeneous system is a homogeneous, distinct entity having a certain composition and a particular set of physical properties. In a phase diagram, relations between these various phases are shown by plotting experimental data so that the different phases occupy regions separated in the diagram by lines representing the limiting equilibrium conditions. From such a diagram, useful generalisations may be made regarding other compositions in a given system or those in related systems. The diagram provides a simple, convenient graphical representation of the relationships between mixed or combined elements or compounds such as occur in steel and other alloys. Melting and freezing points and ranges, transformations, solubilities, and reactions which form intermediate phases and intermetallic compounds are depicted. Eventually, it is hoped, the study of phase diagrams may lead to a theory of alloying that can predict behaviour for compositions and experimental conditions not yet explored.

The well-known two-component, or binary, phase equilibrium diagrams consist of a temperature-composition plot. For such a diagram, the temperature is plotted on the vertical axis against the percentage-composition of the two components on the horizontal axis. Data for these two-component diagrams are obtained from cooling curves recorded in the studies of alloys having various concentrations. Known mixtures are heated to the liquid phase and then gradually cooled while the temperature of the sample is plotted against time. Each time a phase separates out, the cooling curve shows a change in slope because of the heat of reaction. The temperatures at which these changes become evident are then plotted against composition of the alloy.

As an example of a comparatively simple system, a low-melting binary-eutectic diagram (Fig. 1) may be considered. This diagram depicts the lowering of the melting points, M_a and M_b, of each of the pure metals *A* and *B*, by the addition of the other component, and the subsequent formation of a eutectic with a distinct melting point at *E*. If a particular alloy composition, as for example, that of 20 weight per cent metal *B* is cooled down the dashed line from the liquid state to the point *L*, the liquid begins to solidify to form the solid phase of composition *S*. In this case, in contrast to the freezing of a pure metal, the composition of the first solid is no longer that of the original melt, but rather it is that of point *S*, horizontally to the left of *M* ; namely, the solid in equilibrium with liquid *L* at the temperature of *S* and *L*.

Upon additional cooling, the average composition of combined liquid and solid remains 20 per cent of *B*, but the composition of the liquid changes along the curve *LUE* while the composition of the solid follows the curve *STX*. Thus down to the temperature *T*, the solid contains less of *B* than does the original alloy. The liquid composition gradually increases in content of metal *B*, such that when the mixture finally becomes completely solid at the temperature of *XEY*, the last liquid to freeze has the eutectic composition *E*, and the final composition of phase α is that at point *X*. Similar changes are observed at the other compositions within the system which contain combinations of elements *A* and *B*.

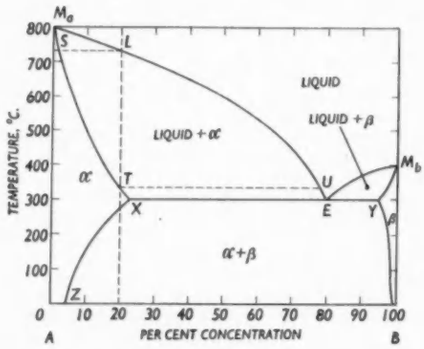


Fig. 1—Representative binary phase equilibrium diagram

One particular composition, in this case that of 80 per cent metal *B*, will exhibit a sharp, distinct, melting point at *E*. This point, called the eutectic point, is the lowest melting combination made up of the elements *A* and *B*. It also is a point on the invariant line *XEY*, the only temperature at which three phases are present in this particular system. Two other areas of particular interest are the solid solubility regions, α and β. This diagram indicates that over 20 weight per cent of metal *B* can be accommodated in the crystal lattice of *A*, provided the temperature is that of line *XEY*.

However, when the solid α phase is at equilibrium below this temperature, it can retain less of *B* and will consist of compositions along the curved line *XZ*. The fact that the solid α loses some of metal *B* as the temperature is lowered is of special significance for precipitation-hardening, a phenomenon which was first explained in 1919 by Merica, Waltenberg, and Scott of the Bureau. An increase in hardness will occur if an alloy in the field of α is quickly cooled (so that it is not in equilibrium), and is then held at a constant temperature as its equilibrium condition is approached. This hardening, caused by the rejection of the *B*-rich β phase, reaches a maximum after a certain period of time at a specific temperature.

Most phase equilibrium diagrams are more complex than this diagram, and may include compounds of certain stoichiometric ratios, shown by vertical lines, which may either melt at a definite temperature or which may decompose to a liquid + solid mixture at a particular temperature. The simplified two-dimensional phase equilibrium diagram does not fully illustrate the wide applicability of such diagrams. The construction of a binary phase diagram is the first step in modern research to develop modern materials. Not only do these simpler diagrams pave the way for the more complex ternary and quaternary alloys, but they themselves provide data for both experimental and theoretical research workers. The production metallurgist uses phase diagrams to determine melting points, annealing temperatures, and approximate forging temperatures ; the theoretician, on the other hand, may be interested in the stability of particular phases as a function of the electronic structure of the elements or compound involved.

Accurate phase diagrams result from the combination of corroborating data obtained by analysing high-purity alloys. Thus one important aspect of phase diagram studies is the development of metals having the highest possible purity. Many of the high-melting metals are difficult to purify and their melting points are generally lowered by impurities. Diagrams plotted from these contaminated metals might not present an accurate picture of the phases occurring in pure metals. The present equipment at the National Bureau of Standards provides extremely pure metals, such as tungsten, by a three-step process : (1) chemically purifying a compound of the metal by fractional distillation; (2) decomposing a volatile halide of the metal in a " hot-wire " apparatus to deposit the metal on the hot wire ; and (3) melting and refining the wire in a floating-zone apparatus using electron-bombardment heating. Specimens of the fused elements in very high purity can thus be made available for basic research on the metal and on its alloy systems.

The possibility of freeing a metal from a specific impurity by zone refinement can usually be predicted from the phase diagram. For example, it might be desired to separate the metal *A* of Fig. 1 from the impurity *B*. If an original alloy rod had the composition *L* and a single drop was melted at one end, the metal which would freeze as the drop was moved along the rod would at first be of the much purer composition *S*. Were this to continue, the liquid drop would soon become so rich in the *B* impurity that no further purification would occur. However, if the original metal was nearly " chemically pure," that is, had much less *B* in it, a useful length of rod could be effectively treated by passing the molten zone along the rod many times, whereby more and more of the impurity *B* could be rejected until finally metal *A* had a purity in the parts-per-million range.

Once a series of alloys is prepared from the component metals, conventional methods of thermal analysis and microscopy are employed to obtain most of the data for phase diagrams. However, because no one procedure can supply

all the data needed, many test methods are employed to examine such structure-sensitive properties as magnetic susceptibility, hardness, and internal friction. In addition, dilation measurements may be obtained over a range of temperatures, and measurements of electrical resistance/temperature may be recorded. X-ray and other diffraction techniques serve to identify various phases, to determine the ordering of atomic structures, and to establish solubility limits.

While analysis involves the continuous measurement or recording of the temperature of the specimen as it is heated or cooled under carefully controlled conditions, differential thermal analysis, a more sophisticated method, determines the temperature of an experimental alloy in comparison with a neutral control substance—i.e., one which has no expected changes over the temperature range under study. Any reaction in the experimental alloy will be revealed as a temperature difference between it and the reference standard. Comparable results should be obtained by the two thermal analysis systems, although the metallurgist selects that particular technique best suited for detecting the specific reaction of immediate concern.

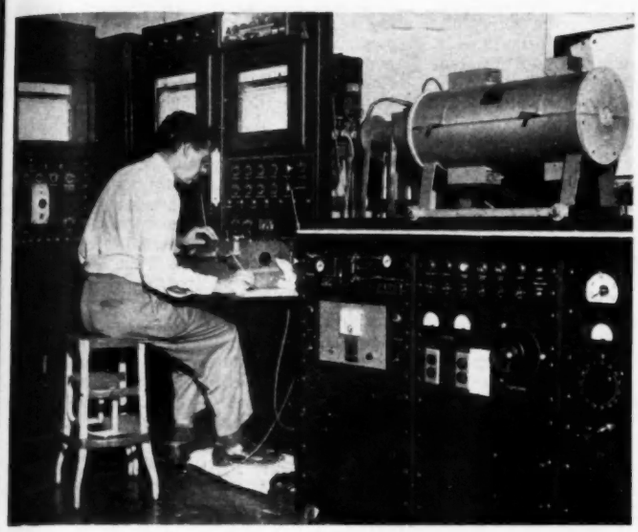


Fig. 2—Apparatus for the precision measurement of electrical resistance and dilation at high temperature

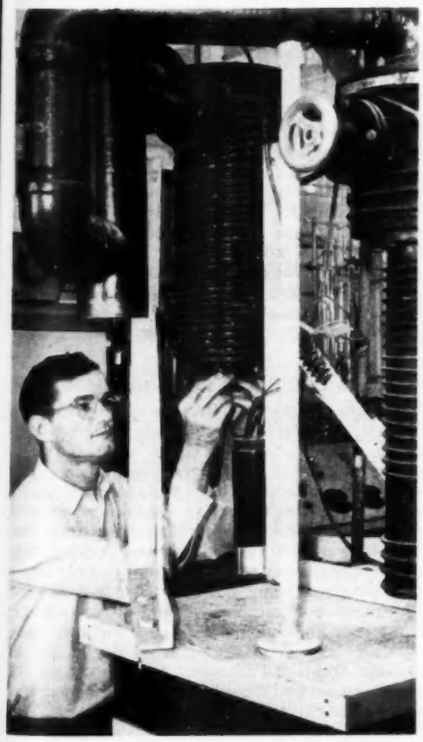


Fig. 3—Thermal analysis equipment used to obtain time *v* temperature data, with a molybdenum-wound resistance furnace

Microscopy, particularly light microscopy, was the first, and is still the most useful technique for determining phase changes, limits of solubility, and type of reaction. In the light microscopy of such opaque materials as metals, the light is reflected from a polished and etched section of a specimen. This procedure reveals a great deal about the microstructure of the specimen. In general, the topological information revealed by the microscope has been qualitatively interpreted by the metallographer in terms of his experience. However, through recent Bureau research, the micrographs can now be directly scanned by high speed computers which provide a quantitative analysis of the microstructural information. For studying more minute structural changes, the electron microscope is employed ; this instrument may detect elements of structure in the range of 10 Angstrom units.

A further advance in this field is the electron-probe microanalyser, which allows determination of the composition of individual grains, precipitated phases, and inclusions *in situ* as composition gradients across diffusion zones. The composition is obtained by analysing the characteristic X-rays emitted from a small area about one micron in diameter—the diameter of the electron beam creating the X-ray excitation. The finely focused electron beam is generated by an electron optical system similar to that in an electron microscope. A light optical microscope is centered on the axis of the electron optical system for viewing the microstructure and positioning the area of interest under the electron beam.

In addition to its use as an auxiliary instrument for obtaining the composition of specific phases, the electron-probe microanalyser is particularly useful as a primary instrument for determining phase equilibrium areas in the solid-state portion of the diagrams, where the sluggishness of the alloy transitions often seriously limits the precision of thermal analysis methods. Equilibrium phase boundaries can be located directly from composition gradient curves which are obtained with the electron-probe from diffusion couple specimens. These are specimens that have been held at selected temperatures in separate furnaces to develop the complete sequence of phases that will occur between the two pure metals at the respective temperatures. Data on the kinetics of the reaction which are not generally determined by thermal analysis techniques are obtained by the electron-probe procedure.

Nuclear magnetic resonance has proved to be an effective tool in revealing aspects of the electronic structure of alloys on which, in part, their phase constitution must depend. The resonance technique utilises the atomic nucleus as a probe to measure magnetic and electric fields inside the metal. Detailed analysis of these fields not only gives information on the electronic densities in metals, but also on relaxation mechanisms, the effects of impurities, imperfections, and atomic ordering. Determination of the electronic structure of the system, i.e., the allowed energy states available to electrons in alloys, can frequently lead to an understanding of alloying behaviour and not merely to a description of it. Metals, alloys, and intermetallic compounds containing nickel, lead, indium, tantalum, niobium, and cobalt are presently being studied.

Current studies at the N.B.S. of phase relationships cover numerous systems ranging from high-temperature metals and alloys to dental amalgams. As part of this programme, systematic studies of the binary phase relationships between uranium and related groups of elements are being conducted in the Metallurgy Division. This study is being sponsored by the U.S. Atomic Energy Commission. Previous investigations to provide information on the alloying behaviour of uranium have dealt with reactions between uranium and beryllium, silver, gold, and platinum, respectively. Although silver, gold, and copper appear in the same group of the periodic chart, their phase diagrams show that the compounds they form with uranium and the shapes of the liquidus curves are far from identical. Thus, although the copper-silver-gold series might be expected to react similarly with uranium, the equilibrium diagrams show that one compound occurs in the U–Cu system, none in the U–Ag system, and two in the U–Au system.

Present work involves studies of the reactions of uranium with the individual platinide metals and with rhenium. Four compounds were found within the U-Pt system. Although the platinide elements have many similarities, platinum can dissolve only 4·5 atomic per cent uranium whereas present studies indicate that palladium dissolves at least 15 atomic per cent uranium. It is necessary to know the reactions of uranium with the platinide metals because ruthenium, rhodium, and palladium are produced in significant amounts during the fissioning of uranium in a nuclear reactor and so must be removed when refining the uranium. Furthermore, the reactions of the platinide metals with uranium are greatly dependent upon their

Fig. 4—Determination of the composition of micro-constituents of a specimen by use of an electron-probe microanalyser

THE AMERICAN SCENE *(Continued)*

individual properties, although these elements are in the same group of the periodic chart.

The work with uranium and related metals has been accelerated by the development of equipment that is especially applicable to high-temperature studies. One instrument utilises the electrical resistance of a specimen so that it may be heated to 2500 deg. Cent. and above when an electric current passes through it. Quenching of the specimen, which is held between water-cooled electrodes, is quickly accomplished by turning off the current. This device has the advantage of operating without a ceramic crucible, thus avoiding the undesirable alloy-crucible reaction which is extremely common when conventional apparatus is used at high temperatures. To study alloy reactions at temperatures up to 1400 deg. Cent., a fully automated thermal analysis furnace has been constructed. This furnace has a controlled heating and cooling rate which may be set at rates between 1 deg. and 5 deg. Cent. per minute and can be operated either under a vacuum or with an inert atmosphere. The apparatus was

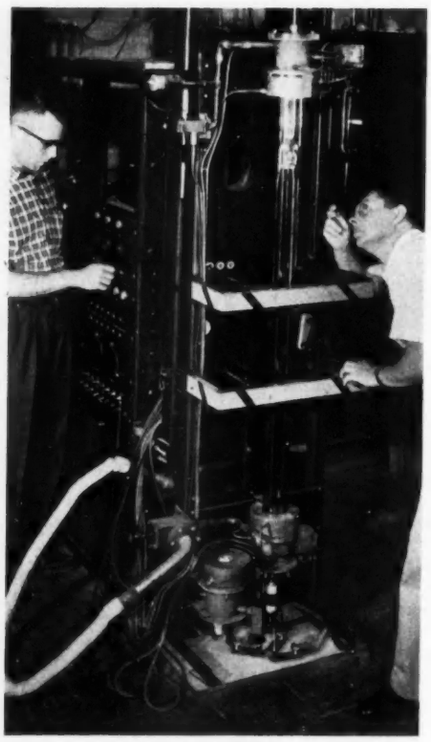


Fig. 5—Zone melting and refining apparatus, with tungsten heating element for bombarding the metal specimen with electrons

modified to permit quenching a specimen in oil after the test material has been slowly heated or cooled to a temperature near a phase reaction.

In the semiconductor field, the Bureau has investigated congruous-melting intermetallic compounds formed between Group III and Group V elements of the periodic chart, such as indium antimonide (InSb). The increasing industrial use of semiconducting devices, such as rectifiers and transistors, together with the present interest in employing semiconductors as infra-red photo-detectors and thermo-electric generators, emphasises the need for a better understanding of the unusual mechanical and electrical properties of these solids. The intermetallic compound, InSb, has been studied in relation to other group III–V compounds such as indium arsenide (InAs). It has also been examined for phase and structural relationships in the pseudobinary systems between these intermetallic compounds. Both the In-Sb system and the In-As system exhibit only the one compound, having the 1 : 1 atomic ratio, with a eutectic on each side of the compound.

A better understanding of the mercury-silver-tin system and of the reactions that occur in the hardening of dental amalgam is of immediate importance to dentistry and may lead to applications in other alloy systems as well. Dental amalgams are made by mechanically mixing a finely divided, solid silver-tin alloy with the liquid mercury. The hardening process then proceeds by isothermal diffusion and by the reaction of the components. It is of interest to note that, in this example of alloy formation with mercury as the solute metal, the same kinds of metallurgical reactions occur at room temperature that require a temperature of nearly 2000 deg. Cent. for such systems as the uranium alloys. The Bureau's dental research staff is now studying the binary tin-mercury alloys to obtain the data required to complete the phase diagrams for this system. In general, experiments so far have indicated that the system is more complicated than previously believed. Results indicate the existence of at least two new phases.

Other phase equilibrium investigations have dealt with materials for highly stable gauge blocks. The Bureau now calibrates industrial master gauge blocks, which are used as standards for controlling the accuracy of mass-produced machine parts, to an accuracy of one part per 1,000,000. In special cases, it has even been possible to certify gauge blocks to an accuracy of better than one part in 5,000,000. To improve the accuracy of gauge blocks even more, suitable alloys for preparing such ultra-precise gauge blocks must be selected. These materials must have sufficient hardness to resist wear, and a high degree of dimensional stability. Through phase-relationship experiments, a nitrided stainless steel was found to have excellent dimensional stability characteristics and is now being further investigated.

Studies on the pyrometallurgical recovery of uranium from spent fuel elements are being conducted for the U.S. Atomic Energy Commission. Economically, the removal of the fission-product elements and the recovery and re-use of the uranium are significant factors in the nuclear energy programme. Potential recovery processes involve the differential solution of uranium and fission products in liquid metals. In these studies the lack of accurate phase diagram information has made necessary the initiation of several binary diagram investigations. Because uranium fission produces a relatively large amount of ruthenium, study of the ruthenium-zinc system has been undertaken.

Phase diagram studies have provided basic information on the many reactions occurring between the components and constituents of metal systems. The present trend in this area is toward an understanding of the forces involved in alloying reactions and the effects produced upon the atom by the addition of another element. A soft X-ray spectrometer is being designed to study the distribution of occupied electron energy levels, thereby providing valuable information on bonding in metals.

Although the binary system is the basic building block for most alloys, ternary or higher diagrams are more frequently employed. For example, in an investigation sponsored by the U.S. Navy Bureau of Ships, ternary studies were utilised to improve the corrosion resistance of the original binary alloy of 60 weight per cent chromium and 40 weight per cent nickel. This binary alloy appears to be highly resistant to the environmental condition in oil-fired Navy boilers. ternary alloys based on Cr-Ni were prepared with a different metal as the third component. The results indicated that small amounts of titanium, yttrium, or magnesium increase resistance of the chromium-nickel alloy to the experimental corrodents which were employed.

Another ternary study is now being conducted on stainless steels. Unknown variables were found to cause erratic performance of one of the stainless steels frequently used for aircraft components. In order to identify these variables, a programme is underway to establish the constitution diagram for high-purity alloys and steels containing various chromium-nickel ratios. This study has been extended to quaternary alloys composed of iron, chromium, nickel, and molybdenum, in which the ratios of certain components are held constant while the others are varied. It is hoped that information will be obtained on the mechanism of formation of the sigma phase found in stainless steels and many other alloys.

Some data have been obtained by progressing from the binary iron-chromium system and other binary systems to the ternary systems involved and, in turn, to the quaternary iron-chromium-nickel-molybdenum system. For example, an examination of the chromium-nickel system has revealed the existence of a previously unreported phase of the beta-manganese type. In addition, a new phase believed to have the composition Mo-Ni has been discovered in the molybdenum-nickel system, and a phase of the $Fe_7Mo_6(Fe_3Mo_3)$ type has been found in the chromium-molybdenum-nickel system.

Although much useful information has resulted from phase equilibrium studies, a great deal more research remains to be done in this field. Thus far, from a potential of more than 5000 binary systems of metallurgical interest, scarcely 900 have been investigated, and a much greater number of higher-order systems are still to be studied.

Voice-Recognition Equipment

An experimental machine which will do arithmetic on voice command has been demonstrated by I.B.M. It is to be used to study the technical feasibility of automatic processing of spoken information.

The device, named " Shoebox," can recognise sixteen spoken words, including ten digits and the instructions " plus," " minus " and " total," the words being converted to electrical impulses and classified according to various types of sound.

The measuring circuit distinguishes between voiced or larynx sounds and unvoiced or frictional sounds formed by lips, teeth and tongue. Words are registered in three parts, the first and last parts being unvoiced and the middle part voiced. For example, the " s " in " six " precedes the vowel and is classified as an early strong frictional syllable. The sound energises the corresponding relay in the machine, and stores this information. Next, the vowel energises the relay for the sound " ih." Finally, the appropriate " frictional-late " relay is energised for the final sibilence of " six." The interconnected storage relays then energises the " six " key on the adding machine. " Shoebox " operates on a principle which allows considerable tolerance to intonation, voice pitch and regional accent.

Stable Computer Storage Elements

Computer magnetic memory cores which can operate without air-conditioning or other temperature compensating devices were shown in public for the first time by the Radio Corporation of America at the Northeast Electronics Research and Engineering Meeting in Boston during November. Measurements of the cores are 0·05in by 0·03in by 0·015in and they will operate without temperature control or current compensation over the range from − 55 deg. to +85 deg. Cent. Previously computers have had to incorporate equipment that would hold the memory temperature between 0 deg. and 40 deg. Cent. or provide additional circuitry to compensate for variations beyond these limits by delivering higher currents to drive the cores. With the new core, however, current requirements vary less than 0·25mV per degree Centigrade. At a driving current of 900mA, the core has a switching speed of 1·1 microsec, making it suitable for memories in the 5 microsec operating range.

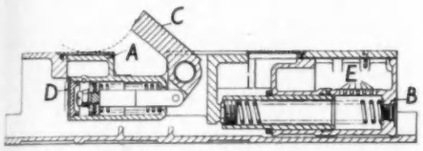
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 4s. 6d. each

RAILWAY EQUIPMENT

881,189. July 28, 1960.—RAIL VEHICLE ARRESTING APPARATUS, Westinghouse Brake and Signal Co. Ltd., 82, York Way, King's Cross, London, N.1. (*Inventors : Francis Wilfrid Derrick and Norman Maris.*)

This invention relates to rail vehicle arresting apparatus of the wheel catch type which is intended more particularly but not exclusively for use in stopping pit tubs on colliery railways. To stop a vehicle by engagement with its wheel presents the problem of the wheel rolling on the rail and simultaneously rubbing against the face of the engaging abutment with the resultant disadvantage of wear between the wheel tread and the abutment face, as well as the inherent tendency of the wheel to climb over the face of the abutment. An object of the invention is to provide an apparatus which minimises the difficulties outlined by arranging that both the face of the abutment and what is effectively the track rail in front of it, recoil simultaneously with the wheel. The apparatus shown comprises a base casting, a wheel stop housing *A* and a hydraulic cylinder *B* providing yieldable resilience for the wheel stop or abutment *C*. The wheel stop housing includes a pneumatic release cylinder *D* by means of which the stop may be raised and lowered to and from a wheel engaging position. The stop housing with the release cylinder and stop slides on runners (not shown) on the base casting. When the wheel of a vehicle runs



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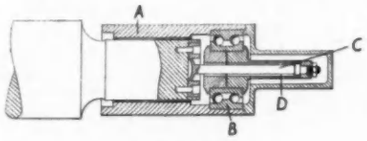
on to the housing and engages the raised stop, both the wheel and the housing move against the yielding resistance afforded by the hydraulic cylinder *B*. Since the wheel is actually supported by the housing, any tendency of the wheel to climb over the stop is reduced whilst wear between the wheel tread and face of the stop is minimised. As the housing is directly in contact with the hydraulic cylinder, the movement of the vehicle is transmitted to the liquid which is displaced through the orifices *E* in the walls of the cylinder into the reservoir, thereby dissipating the kinetic energy of the vehicle. Upon the vehicle coming to rest, the housing, and vehicle are returned to the initial position by the spring in the hydraulic cylinder, which is compressed by the movement of the piston towards the reservoir end of the cylinder. The orifices *E* are blanked off progressively in the stroke of the piston thus providing a reasonably uniform retardation effect, the liquid passing from the cylinder into the sealed reservoir also causing a slight increase in pressure in the enclosed air.—*November* 1, 1961.

ROLLING MILLS

881,297. December 21, 1959.—BEARINGS FOR THE ROLLS OF ROLLING MILLS, Aluminium-Industrie-Aktien-Gesellschaft, Chippis, Canton of Valais, Switzerland.

Axial thrust bearings of the rolls in rolling mills have the disadvantage that they are rigidly coupled with the journals of the rolls, so that the roll deflections which are unavoidable in operation are transmitted to the thrust bearing. This causes a large amount of friction and a rise in temperature or wear of the bearing parts. These drawbacks are stated to be obviated by the invention. The drawing shows schematically and by way of example one of two practical embodiments of the invention described in the specification. The roll rests with



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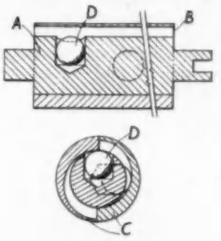
its journal in a bearing *A* which is fastened in the rolling stand. In the housing of the bearing is also fixed the outer ring of a thrust bearing *B*. The end of the roll journal is connected to the inner ring of the thrust bearing through an elastic device which comprises a rod *C* screwed on the end of the journal. A sleeve *D* surrounding the rod is fastened to the inner ring of the thrust bearing. At their free ends the rod and the tube are also connected, so that the axial stresses on the roll become transmitted through the rod and the tube to the thrust bearing. Both the rod and the tube are of such shape and size that they have a sufficient strength for transmitting the axial stresses as well as sufficient elasticity for taking up the radial deflections occurring at the end of the roll journal.—*November* 1, 1961.

VIBRATORS

881,093. May 30, 1960.—VIBRATORS, J. W. and T. H. Carter Ltd., 83, Sharp Street, Hull, Yorks., and George Malbon, 149, Westfield Place, Acomb, York.

This invention has for its object to provide a mechanical vibrator, capable of generating high frequency vibrations, and is such that by design changes the frequency or amplitude or both may be varied between wide limits. As illustrated in the drawings, the vibrator comprises a cylindrical rotor *A* having end extensions which support it in anti-friction bearings. The cylindrical housing *B* is formed with two internal surface cams *C* each of which terminates in a step. Along its length the rotor has angularly spaced radial bores in each of which is a freely movable steel ball *D*. When the rotor is driven at high speed the balls are subjected to centrifugal



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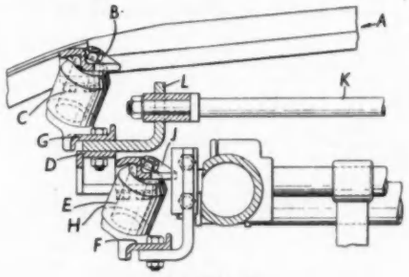
force which tends to eject them from their bores. The balls roll on the cam surfaces and are thereby pushed back into their respective bores until a ball passes over the step at the highest point of a cam surface when it flies out and strikes the housing at the shallowest part of the adjacent cam surface. Each ball strikes the housing twice for each revolution of the housing. The frequency of the vibration thereby imparted by the balls depends on the speed of rotation of the rotor and the number of balls with the amplitude depending on the mass, or size, of the balls.—*November*, 1961.

ELECTRIC TRACTION

882,315. August 18, 1959.—PANTOGRAPH CURRENT COLLECTORS, J. Stone and Co. (Deptford) Ltd., Deptford, London, S.E.14. (*Inventor : Charles Valentine Austin.*)

An object of the present invention is to provide a highly flexible pantograph current-collector head able to cater for the high frequencies of vibration in the vertical plane imparted by the now customary overhead catenary system as a result of the droppers holding the contact wire and of the stagger points at posts or other supporting fixtures. A further object is to eliminate or reduce wearing parts associated with spring-loaded links and levers, pins and bushes found in known pantograph collector assemblies. In the example illustrated the main collector bow *A*



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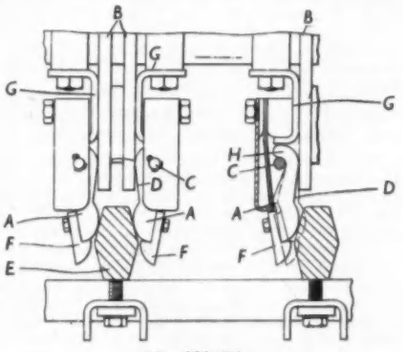
is supported through each cross piece *B* by a pair of resilient mountings *C* from an intermediate cross piece *D* which is in turn supported by a further pair of resilient mountings *E* from a lower cross piece *F*. The latter is carried by a bracket clamped on the adjacent end of the usual shaft at the head of the pantograph. The arrangement shown is, of course, duplicated in mirror-image fashion towards the other end of the bow. The axes of the mountings *C* between the cross member *D* and brackets *G* bolted to the cross member are inclined upwardly, at about 30 deg. to the vertical, towards each other and also inwardly, at 90 deg. to each other, and towards the middle of the bow, i.e. towards the position of the overhead contact wire. Each mounting *C* is of the nature of a rubber sandwich. It comprises two rubber cushions welded between an intermediate metal disc, and metal discs secured by bolts to the members *B* and *C* respectively. The whole mounting is freely enclosed in a canopy *H*. The mountings *C* afford vertical as well as fore and aft flexibility. Limited transverse tilting and displacement are also permitted. The mountings *E* are similar to the mountings *C* and are arranged, between brackets *J* bolted to the member *D* and the member *F*, in substantially the same manner and with the same inclinations, except that they are inset nearer to the middle of the pantograph structure. The mounting assemblies towards the two ends of the bow are braced apart by a transverse rod *K* having its ends fixed in brackets *L* bolted to the cross member *D*. By means of this rod, the rubber mountings *C*, *E* can be placed under initial stress, and the whole resilient mounting given stability. The mountings *E* serve particularly to augment the flexibility in the vertical direction. Combinations of rubber mountings such as have been described permit a very large vertical deflection, but limited deflection in other planes. Damage due to "hard spots" along the contact wire is minimised and the currents picked up by the individual contact strips are well equalised. Also the motion of the collector head against the wire is effectively stabilised.—*November* 15, 1961.

ELECTRICAL ENGINEERING

882,691. March 12, 1959.—ELECTRIC CIRCUIT-BREAKERS, Ottermill Switchgear Ltd., Ottery St. Mary, Devonshire. (*Inventor : Edward Gordon Wright.*)

In an electric circuit breaker according to this invention the electrical connection between the terminal contact member and a bridging member between it and the moving contact is effected without requiring a flexible connection or specially shaped joint. Referring to the drawing, bridging members or fingers, are seen at *A* and are urged towards plates *B*, the terminal members by leaf springs. When the circuit breaker is open, the "hook" ends, *H*, of the fingers (seen on the right of the drawing) rest against



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pins *C*, and faces *D* of the fingers engage the outer faces of plates *B*. When moving contacts *E* are lifted to close the breaker, they first engage the arcing tips *F*, turning the fingers back against the spring force so that the convex surfaces of their "hook" ends roll against plates *B*. The fingers are also moved round the pins and make contact with the lower portions of brackets *G*. Any arcing as a result of contact chatter takes place here, so protecting the contact between plate and hook. When contacts *E* are withdrawn, the fingers move back in engagement with pins *C* and arcing again occurs between the hooks and the horizontal surfaces of brackets *G* so as to avoid or reduce the formation of arc between the plate and the hook. The rolling action between these two elements serves to keep the co-operating surfaces clean.—*November* 15, 1961.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London. W.1.

DEFINITIONS OF THE CALORIFIC VALUE OF FUELS

No. 526 : 1961. Price 6s. In the new edition of this specification definitions of gross and net calorific value are given both for constant volume and for constant pressure. Separate definitions are given for solid and liquid fuels and for gaseous fuels because the use of a specific calorimetric method is essential to the definitions for solid and liquid fuels.

The temperature, 25 deg. Cent., which has been accepted as the international thermo-chemical reference temperature, is recommended for the expression of calorific value instead of the temperature 60 deg. Fah. adopted in the original standard. The conditions recommended for the measurements of the volume of a gas are a temperature of 60 deg. Fah. (15.6 deg. Cent.) a pressure of 1 standard atmosphere (1 atmosphere) and complete saturation with water vapour.

The choice of 1 atmosphere as the standard pressure for measurement of volume, together with the reference temperature 25 deg. Cent., prescribed in the definition of calorific value, makes the calorific value defined in B.S. 526 differ from that in the Gas Act, 1948, which must be used when any gas is subject to the requirements of the Act. However, the effect of this difference in the definitions is small.

LIGHTING FITTINGS FOR CIVIL LAND AERODROMES

Section D2 : " Omni-Directional Elevated Runway-Lighting Fittings. Price 4s. 6d.
Section D6 : " High-Intensity Elevated Runway-Threshold Lighting Fittings." Price 4s. 6d.
Section D7 : " Omni-Directional Elevated Runway-Threshold Lighting Fittings." Price 4s. 6d.

No. 3224 : 1961. All British Standard Specifications for lighting fittings for use at civil land aerodromes are now being published as sections of one standard, B.S.3224, and the standard bearing this number (High-Intensity Elevated Runway-Lighting Fittings ") has been renumbered : B.S.3224 : Section D1. The three more sections of Part D now published are as listed above. They specify requirements and test for the photometric performance and the essential mechanical and electrical features (excluding lamps) for the fittings they cover. These fittings are suitable for use on systems with a maximum voltage of 50V r.m.s to earth. Guidance on the use of the fittings is given in B.S.1332, " Guide to Civil Land Aerodrome Lighting."

ANTI-STATIC RUBBER FLOORING

No. 3398. Price 4s. Where electrical equipment is used in which the development of a fault could give rise to the risk of electric shock or fire (e.g. in hospital operating theatres), it is essential that the rubber flooring, while being sufficiently conducting to disperse static charges, should also have sufficient resistance to limit to a safe value any leakage current from the electrical installation or apparatus through the floor to earth. Consequently rubber flooring for this field of application must have a resistance lying within a prescribed range with both the upper and lower limits clearly defined. Material with these electrical characteristics, designated " anti-static," forms the subject of the above standard.

OIL RESISTANT COMPRESSED ASBESTOS FIBRE JOINTING. AMENDMENT

Amendment. No. 1832 : 1958 (PD 4129). Price 4s. Recent experience has shown that the ignition loss test and " with grain " tensile test laid down in B.S. 1832 for oil resistant compressed asbestos fibre jointing are not of great value in selecting suitable jointing material. What is needed, to exclude unsuitable material, is a test at high temperature under pressure. An amendment to B.S. 1832 was therefore published recently (PD 4129). It deletes the ignition loss and " with grain " tensile tests and adds a new stress relaxation test. Details of the method, the apparatus and its calibration, and minimum stress relaxation values for $\frac{1}{16}$in thick jointing are given in this nine-page amendment.

ABRASIVE PAPERS AND CLOTHS FOR GENERAL PURPOSES

No. 871 : 1961. Price 7s. 6d. The 9in by 11in (230mm by 280mm) is specified in this revised edition of B.S. 871 dealing with abrasive papers and cloths for general purposes. The publication, in which the figures for grading and tensile strength, have been revised covers emry cloth, glass cloth, glass paper and sheet flint paper, but does not include flint cloth which has fallen out of general use.

A metal removal test for emery cloth is now described, and minimum acceptance values are given. To assist buyers and suppliers, recommendations on the ordering of these products are also included.

SAFETY VALVES, GAUGES, AND OTHER SAFETY FITTINGS FOR AIR RECEIVERS AND COMPRESSED AIR INSTALLATIONS

No. 1123 : 1961. Price 4s. To keep pace with the increasing use of compressed air this publication has been revised and enlarged and, although the main provisions of the standard remain unchanged, modifications have been made to secure co-ordination with the 1955 edition of revised B.S. 759, " Valves, Gauges, and other Safety Fittings for Application to Land Boilers and Piping Installations for and in connection with Land Boilers." The most important of these modifications is the permissible use of safety valves having an established discharge greater than provided for by the minimum aggregate area formula. The revision also includes a comprehensive specification covering the requirements for safety valve springs.

Code of Practice

MAINTENANCE OF ELECTRIC MOTOR CONTROL GEAR

Code 1011 : 1961. British Standards Institution, British Standards House, 2, Park Street, London, W.1. Price 6s.—A new Code of Practice on the maintenance of electric motor control gear has been published by the British Standards Institution under the authority of the Council for Codes of Practice. The code provides guidance on matters which experience has shown to be of major importance in keeping electric motor control gear in efficient condition. Statutory regulations with which electrical installations may have to comply are indicated, together with such general matters as inspection, observance of manufacturers' instructions, and the analysis of faults. A section dealing with the safety of personnel emphasises precautions, such as isolation before maintenance ; the use of voltage indicators ; special precautions in dealing with oil-immersed equipment ; and the maintenance of earthing connections. Notes are included on first-aid and fire extinguishing equipment. The main section of the code sets out general principles of maintenance which are applicable to most types of equipment, followed by detailed recommendations for various types of control gear such as contactors, drum controllers, overload and time-delay devices, liquid starters and controllers, pushbutton and similar auxiliary devices, isolators and composite units of switches and fuses. There is a list of special equipment (other than tools normally used by the electrician) which may be needed for carrying out the recommendations of the code.

Catalogues and Brochures

THE GAS COUNCIL, Murdock House, 1, Grosvenor Place, London, S.W.1.—Brochure entitled " Modern Foundry Practice," illustrating and describing the uses of gas in ferrous and non-ferrous foundries. Sand, mould and core drying, shell moulding, cuplao lighting, ladle drying and heating, heat treatment and metal melting are among the subjects covered, and there are also notes on certain applications of gas, such as space heating which, though used in foundries are also of general industrial interest.

DISTINGTON ENGINEERING COMPANY LTD., P.O. Box 8, Workington, Cumberland.—Illustrated brochure " The Iron Foundry," giving details of the products and manufacturing facilities of the Distington works foundry. The works started as an iron foundry in 1946, and has an output of more than 2800 tons of heavy castings a week. It also operates a steel fabrication shop and a heavy machine shop, and produces its own patterns. Ingot moulds, slag ladles and other heavy castings for steelworks are among the main products of Distington foundry, but castings of all kinds up to 120 tons weight are made for the engineering industry. Castings are made in any one of three main grades ; hematite, grey iron and low alloy irons. Spheroidal graphite iron castings are also produced.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Dec. 15.—COVENTRY AND DISTRICT BRANCH : Conservative Rooms, 16, Queens Road, Coventry, " A Simple Approach to Computers," M. M. Robins, 8 p.m.
Mon., Dec. 18.—BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Bristol, " Fire Alarms," D. E. Williams, 8 p.m.
Thurs., Dec. 21.—SOUTH LONDON BRANCH : Greyhound Hotel, Croydon, Surrey, " Manufacture of Foodstuffs," R. B. O. Harwood, 8 p.m.
Thurs., Dec. 28.—NORTHERN IRELAND CENTRE : Central Hall, Rosemary Street, Belfast, Film, " See It Now—Automation," 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Dec. 20.—TECHNICAL COMMITTEE : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Programme of Technical Films, 6 p.m. ★ SOUTH WESTERN SECTION : School of Management Studies, Unity Street, Bristol, Annual General Meeting, and " Transistors in Transmitters and Communications Receivers," D. C. Carey, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Dec. 19.—EAST ANGLIAN SECTION : Lecture Theatre, Civic College, Rope Walk, Ipswich, Film Evening, 7.30 p.m.

INSTITUTE OF METALS

Tues., Dec. 19.—BIRMINGHAM LOCAL SECTION : Large Lecture Theatre, Birmingham and Midland Institute, Paradise Street, Birmingham, Christmas Lecture for Schoolchildren, " Science in the Service of Metallurgical Industry," H. Morrogh, 2.30 p.m.

INSTITUTE OF NAVIGATION

To-day, Dec. 15.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Films, 5.30 p.m.

INSTITUTE OF SEWAGE PURIFICATION

Wed., Dec. 20.—METROPOLITAN AND SOUTHERN BRANCH : Main Hall, Friends House, Euston Road, London, N.W.1, One-day Symposium on " The Treatment of Industrial and Sewage Sludges," 9 a.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 19.—Great George Street, Westminster, London, S.W.1, " The Hirfanti Hydro-electric Scheme," G. B. Finch and N. K. Webb, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Dec. 18.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, " Large Microwave Steerable Aerials for Communication with Artificial Earth Satellites and Space Probes," F. J. D. Taylor, 5.30 p.m. ★ NORTH LINCOLNSHIRE DISTRICT AND THE SHEFFIELD SUB-CENTRE : Angel Hotel, Brigg, Discussion on " Apprentice Training," opened by A. L. P. Carter, F. C. Jones and N. L. Evans, 7 p.m. ★ MERSEY AND NORTH WALES CENTRE : Royal Institution, Colquitt Street, Liverpool, " Education of an Electrical Engineer," M. R. Gavin, and " The Place of Formal Study in the Post-Graduate Training of an Electrical Engineer," N. N. Hancock, and P. L. Taylor, 6.30 p.m. ★ NORTH EASTERN MEASUREMENT AND ELECTRONICS GROUP : Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, " Heaviside—His Life and Work," R. L. Russell, 6.15 p.m.
Tues., Dec. 19.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, " The Use of Controllable Semiconductor Rectifiers in Machine Control," K. G. King, 5.30 p.m.
Wed., Dec. 20.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, " Satellite Instrumentation," R. L. F. Boyd, 5.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

To-day, Dec. 15.—LIVERPOOL AND DISTRICT BRANCH : Exchange Hotel, Tithebarn Street, Liverpool, Ladies' Evening, 6.30 p.m.
Tues., Dec. 19.—SCOTTISH BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, " Vibration Isolation," E. H. Sims, 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Thurs., Dec. 21.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, " The Engineering Aspect of Catering on Trains " : " British Railway Experience," H. Wilcock, " Overseas Experience," W. E. Bulman, and " From the Catering Manager's Viewpoint," H. Simons, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Dec. 16.—SCOTTISH BRANCH, GRADUATES' SECTION : Visit to the Kinneil Colliery at Boness, 9.15 a.m.
Mon., Dec. 18.—EDUCATION AND TRAINING GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, " The Teaching of Machine Tool Technology as an Academic Subject," 6 p.m. ★ SCOTTISH A.D. CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " Comparison of the Wear of Small Gasoline and Diesel Laboratory Engines," W. C. Pike and P. Newman, and " An Investigation into Factors which Affect Piston Ring Wear Under Starting Conditions," J. C. G. Cree and J. Thiery, 7.30 p.m.
Tues., Dec. 19.—MIDLAND BRANCH : City Museum and Art Gallery, Birmingham, Ladies' Evening, 7 p.m. ★ LONDON BRANCH GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, " Grand Prix Motor Racing," A. F. Rivers-Fletcher, 6.30 p.m.
Wed., Dec. 20.—INTERNAL COMBUSTION ENGINES GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, " Effect of Ambient Conditions on the Performance of Turbo-charged Diesel Engines," 6 p.m. ★ NORTH EASTERN A.D. CENTRE : The University, Leeds, " Automotive Lubricants and Lubrication," A. Towle, 7.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Dec. 21.—Geological Society, Burlington House, Piccadilly, London, W.1, " Dependence of the Floatability of Antimonite on the Value of Zeta-Potential," B. V. Derjaguin, and " Radon Determination as a Prospecting Technique," J. D. Peacock and R. Williamson, 5 p.m.

INSTITUTION OF PLANT ENGINEERS

Wed., Dec. 20.—KENT BRANCH : South Eastern Gas Board Lecture Hall, 95, High Street, Rochester, " Molybdenum Disulphide as a Lubricant," D. E. Burton, 7 p.m.
Thurs., Dec. 21.—BLACKBURN BRANCH : Castle Hotel, Blackburn, " The Merits of Various Heat Generation and Distribution Systems," R. A. Wiggans, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 15.—Pepys House, 14, Rochester Row, London, S.W.1, Inaugural Meeting and Presidential Address, " The History and Work of the Railway Inspectorate—Ministry of Transport," C. A. Langley, 7.30 p.m.
Fri., Dec. 29.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " The Turn of the Century : A Pictorial Survey," J. Foster Petree, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Dec. 15.—Mining Institute, Newcastle upon Tyne, " Investigations into the Strength of Underdeck Girders Carried Out at Glengarnock," K. V. Taylor and J. S. Shand, 6.15 p.m.

PLASTICS INSTITUTE

Thurs., Dec. 28.—MIDLANDS SECTION, REINFORCED PLASTICS GROUP : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, " Survey of New Developments in Resin," H. R. Everard, 7 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., Dec. 20.—49, Cromwell Road, London, S.W.7, " Thermal Structure in the Lower Layers of Anticyclones," J. Findlater ; " A Graphical Method of Objective Forecasting Derived by Statistical Techniques," M. H. Freeman, and " A Three-Parameter Model of the Atmosphere Suitable for Numerical Integration," F. H. Bushby and Clare J. Whitelam, 5 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Dec. 20.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, A Discussion of Recently Published Papers, " Experimental Survey of Rust Preventives in Water," and " Corrosion of Metals by Acid Vapours from Wood," 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Dec. 21.—GRANGEMOUTH SECTION : Leapark Hotel, Bo'ness Road, Grangemouth, " Instrumentation of Space Vehicles," A. E. Roy, 7 p.m.